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BINOMIAL RELIABILITY CURVES FOR PLANNING AND ASSESSMENT

D. R. Cruise, et al

Naval Weapons Center
China Lake, California

August 1975

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by

D. R. Cruise

G. A. Tabb

I. S. Kurotori

Propulsion Development Department

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CHINA LAKE, CALIFORNIA 93555

Naval Weapons Center

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

R. C. Freeman, III, RAdm., USN . . . . Commander

G. L. Hollingsworth . . . . Technical Director

FOREWORD

This report describes an investigation conducted during the period January through March 1975, sponsored by the Naval Air Systems Command under AirTask A5109/008D/5W11-74-0000 Work Unit A5109E-02.

This report has been reviewed for technical accuracy by Warren W. Oshel.

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(U) *Binomial Reliability Curves for Planning and Assessment*, by D. R. Cruise, G. A. Tabb, and I. S. Kurotori. China Lake, Calif., NWC, August 1975. (NWC TP 5728, publication UNCLASSIFIED.)

(U) Graphs are presented that (1) guide the user in determining the numbers of items to be tested to determine lower reliability limits (R_L) at a confidence level (C_L), (2) establish R_L at C_L after testing N (sample size) items, (3) given the true reliability, allow determination of the probability of failing to demonstrate R_L, (4) provide an operating characteristic curve for a given N and the number of items in a sample that pass a given test (S), (5) establish upper reliability limits, given N and S, and (6) allow utilization of the Bayesian approach.

CONTENTS

INTRODUCTION

A question of the utmost importance to the users of any weapon is "How good is the item/weapon?". More specifically, the question is "How well does it perform its intended function?" or "How reliable is the weapon?". Since weapon reliability is a function of design, it is the designer's job to address this question and to supply the user with reliability data.

If each weapon could be functionally tested, the problem would be greatly simplified. The user would receive those passing the test and the failures would be scrapped or repaired. However, since most weapons are one-shot items, 100% testing would leave nothing for delivery to the user. The solution is to test a sample from a population, then make predictions (statements) about the population.

Since the reliability prediction of the weapon population is based on a sample, uncertainty of the reliability prediction necessarily follows. Of course, if more weapons are tested the degree of certainty will increase. This is where the term confidence level comes to play, as it is the probability that the reliability prediction is true. Another factor that must be considered is the risk involved in achieving the required reliability prediction. This risk is a function of the true reliability of the weapon.

The problem reduces to (1) what reliability prediction does the designer wish to make and at what confidence level, (2) how many items should be tested, and (3) what are the risks involved in being able to achieve the reliability prediction at a specified confidence level.

This report presents 101 graphs of the entire spectrum of confidence levels and the associated reliabilities for each sample size from 1 to 101. These graphs (binomial reliability curves) can be helpful to managers, engineers, and the technical planners during the time that reliability decisions are being formulated and carried out.

Reliability is shown from 0.5 to 1. However, since the curves for 0 to 0.5 are symmetrical to those for 0.5 to 1, the reliability for 0 to 0.5 region may be read by turning the graphs upside down.

Confidence levels are given in percent. In addition to those labeled, tick marks indicate the levels for 0.5, 15, 25, 35, 45, 55, 65, 75, 85 and 99.5%. The scale has been stretched at both ends to make it more readable.

Curves are given for each possible number of successes. Sufficient numbers are provided on the curves to make each one easily identifiable. Again, for those numbers of successes that result in a curve entirely below the 0.5 reliability level, the graph must be turned upside down.

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Persons knowledgeable in the reliability field may ask, "Why include ridiculously low reliability and confidence levels in the graphs?" The reasons are readily apparent when the curves are used over the full spectrum of intended applications. Often, limited and restricted tests result in low statistical values. Without a full set of curves, the engineer would only know that the situation is bad. With the curves for the low values, he knows the exact statistical situation. Also, a full set of curves allows a quick visual analysis or overview for a given sample size (up to 101). This quick-look analysis can aid managers and engineers in selecting a sample size that will best demonstrate their requirements and still be within budget constraints.

The graphs are designed for flexibility, maximum readability, and optimum use. Given the sample size and number of successes, it is easy to determine

1. Lower reliability bounds and associated confidence levels.

2. Reliability intervals for given confidence levels.

Conversely, given a stated reliability at a stated confidence level, the graphs can be used to determine

1. The number of successes needed for a given sample to meet the stated requirements.

2. Whether the sample falls within predetermined risk limits.

It should be noted that similar curves are published by Thorne[1] and tables are published by Cooke.[2] However, Thorne's work was accomplished prior to the recent advances in computer graphic technology, which are used to the fullest extent in the curves published in this report. Cooke's work is recommended when specific confidence levels at a high degree of accuracy are required; however, the curves presented herein are easier to use and provide a clearer overall picture at an acceptable, albeit lower, accuracy (three places). Also, the curves are not restricted to the specific confidence levels given in the tables.

The following present a definition of symbols, examples of the various uses of the curves, and a discussion of the theory upon which the curves are based.

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[1] Naval Missile Center. *Reliability and Confidence Limits for Sample Testing*, by C. J. Thorne and R. W. Claassen. Point Mugu, CA, NMC, April 1968. (Report NMC-MP-68-2.)

[2] Naval Ordnance Test Station. *Binomial Reliability Table*, by James R. Cooke, Mark T. Lee and John P. Vanderbeck. China Lake, CA, NOTS, January 1964. (NOTS TP 3140 (NAVWEPS 8090))

SYMBOLS

N	Sample size, number of items tested
S	Number of items in N that pass a given test
R	Population reliability, inherent probability that an item will perform its intended function
R_L	Lower reliability limit, an estimate based on sample testing
C_L	Confidence level that $R > R_L$, given S and N
R_U	Upper reliability limit, an estimate based on sample testing
C_U	Confidence level that $R < R_U$, given S and N

USE OF THE CURVES

As stated previously, the graphs are designed for flexibility, readibility, and optimum use. The following six examples of how to use the graphs correlate with the six applications listed in the abstract.

EXAMPLES

EXAMPLE 1 - DETERMINATION OF R_L AT A GIVEN C_L

Your warhead development program has advanced to the stage where testing should be conducted to demonstrate that the warhead is reliable. You want to demonstrate at least a 0.75 reliability at the 90% confidence level. The problem then is to determine how many tests are required to do this. By looking at the graphs, you find that it can be done by:

1. Getting 8 successes out of 8 tests.
   (This was done by finding a point defined by 0.75 reliability and 90% confidence level that coincides with (S = N) and (N). Any value of N less than 8 will not yield the desired prediction. In a similar manner, subsequent graphs yield values of S and N that allow a reliability prediction of at least 0.75 at the 90% confidence level. Naturally, as N increases, more failures can occur and still allow the desired reliability to be demonstrated.)

2. Getting 13 successes out of 14 tests.

3. Getting 18 successes out of 20 tests.

4. Getting 22 successes out of 25 tests.

5. Getting 26 successes out of 30 tests

6. Getting 30 successes out of 35 tests

7. Getting 34 successes out of 40 tests

8. Getting 38 successes out of 45 tests

9. Getting 42 successes out of 50 tests

The next step is to select one of the above options. This consideration, which should be based on the design reliability and the risk you wish to accept, is shown in Example 3.

EXAMPLE 2 – ESTABLISHING R_L AT C_L AFTER TESTING N ITEMS

You are developing a rocket motor and have fired 32 motors with 2 failures. You would like to know the reliability of the motor. The best estimate of the motor reliability is, of course, 30/32 = .9375, but how much lower can the true motor reliability be? This depends on the confidence level with which you would like to make the lower reliability limit statement. Using the N = 32 graph, you may make statements such as:

1. You are 90% confident that the reliability is at least 0.843. (This is the reliability at the point where the 90% confidence level intersects the S = 30 curve.)

2. You are 80% confident that the reliability is at least 0.872.

3. You are 70% confident that the reliability is at least 0.890.

4. You are 60% confident that the reliability is at least 0.905.

5. You are 50% confident that the reliability is at least 0.917, etc.

EXAMPLE 3 – DETERMINATION OF THE PROBABILITY OF FAILING TO DEMONSTRATE R_L AT C_L, GIVEN TRUE RELIABILITY

You have designed a fuze to have a reliability of 0.99 and wish to demonstrate that the reliability is at least 0.90 at the 90% confidence level. You also wish to have a small risk of failing to demonstrate this.

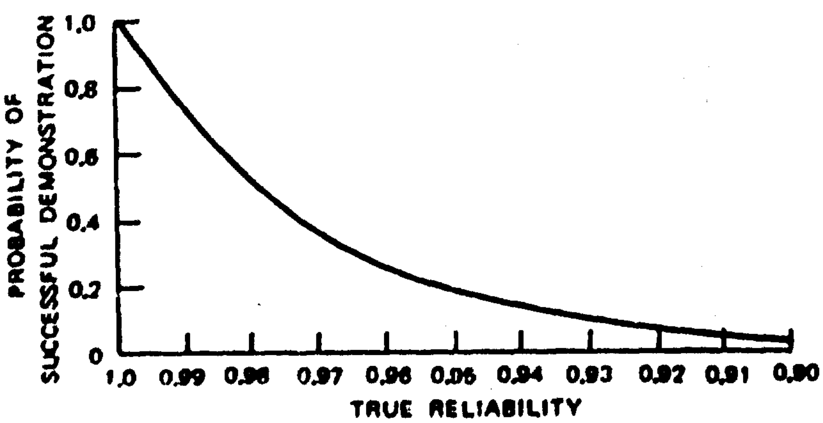
Consider two choices. From Graphs N = 22 and N = 38, you can see that if 22 are tested without failure or if 38 are tested with no more than 1 failure, the fuze will have demonstrated a reliability of at least 0.90 at the 90% confidence level. The probability of getting 1 or more failures in 22 tests when the true (or assumed) reliability is 0.99 is 0.20. (This probability is the confidence level at the intersection of 0.99 reliability and the S = 22 curve.) The probability of getting 2 or more failures in 38 tests when the true reliability is 0.99 is 0.05 (where S = 37 intersects 0.99). You may therefore decide to test 38 fuzes instead of 22, because the risk of failing to demonstrate 0.90 reliability at 90% confidence is 4 times greater with 22 samples (0.20 failure probability) than with 38 samples (0.05 failure probability).

EXAMPLE 4 CONSTRUCTING AN OPERATING CHARACTERISTIC CURVE GIVEN N AND S

Thirty two igniters have been produced for testing to demonstrate reliability. You do not know the true reliability; however, you would like to know (1) what maximum lower reliability limit can be demonstrated at the 90% confidence level, and (2) what are the probabilities of being able to do this as a continuous function of true reliabilities.

1. From the N = 32 graph, the best that can be demonstrated at the 90% confidence level is 0.93 reliability (S = 32 curve, no failures).

2. The probabilities as a continuous function of true reliabilities are obtained by drawing an operating characteristic curve from the S = 32 curve (N = 32 graph). This curve is constructed by subtracting the confidence level from 100 ($100 - C_L$) for all reliability values on the S = 32 curve and plotting as shown below. $100 - C_L$ is the probability of demonstrating 0.93 reliability at the 90% confidence level. For example, if the igniter's true reliability is 0.97, you have about a 0.37 probability of demonstrating 0.93 reliability at 90% confidence level. (Compare with method in Example 3, which would show the probability of not demonstrating 0.93 reliability at 90% confidence, to be ~ 0.63, i.e., the probability of success is 1.00 minus the probability of failure.)



EXAMPLE 5 ESTABLISHING UPPER RELIABILITY LIMITS, GIVEN N AND S

A new pyrotechnic formulation has been developed to increase the heat output of a flare to a required level. Thirty-two flares were produced from a batch (mix) of this formulation and tested; 3 failed to meet the required heat output. The reliability requirement on the heat output is 0.95. With the given data, can you say, with 90% confidence, that the true reliability of meeting the heat output is less than 0.95? Go to the N = 32 graph and turn it upside down so the first curve on the left is labeled 1 (read the 0 to 0.5 reliability scale). Go to the intersection of 90% confidence and the curve labeled 3 (3 is not labeled, but 1 and 4 are), then read the reliability scale (0.035). This is equivalent to stating that the probability of failure is at least 0.035 at the 90% confidence level which is the same as stating that the reliability is at most 1 − 0.035 = 0.965 at the 90% confidence level. Therefore, the reliability that the flare will produce a heat output meeting requirements may, in fact, be 0.95.

However, if there had been 5 failures, the reliability would be at most 0.922 at the 90% confidence level. In this case, we would suggest "going back to the drawing board".

EXAMPLE 6 UTILIZING THE BAYESIAN APPROACH

The previous examples present the most commonly used approach. There are admitted difficulties[3] (see footnote 1) in this usage, steming from the fact that one is not actually sure which curve to use. Compare Example 2 with Example 5 and note that different curves are used for the upper and the lower confidence limits. Actually, the curves that are chosen express pessimistic results.

Fortunately, the approach of Bayes and Laplace does not have these difficulties. Even more fortunately, the Bayesian approach may use these same graphs.

The correct Bayesian curve is found by adding one to both the number of successes and the number of tests (this is explained under Theory). Thus, in Example 2, where 30 motors were successfully fired out of 32 attempts, you would use the S = 31 curve on the N = 33 graph. This curve crosses the 90% confidence line at 0.846.

To find the upper confidence limit at 90% confidence as in Example 5, follow the *same* curve to the 10% confidence line and read 0.963.

Compare the results of Examples 2, 5, and 6 for 30 successes in 32 tests.

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[3] Pearson, E. S., and H. O. Hartley. *Biometrika Tables for Statisticians.* Cambridge, England, Cambridge University Press, 1966. Vol. 1, pp. 83-84.

[4] Jaynes, E. T. "Confidence Intervals vs. Bayesian Intervals." Presented at the *International Symposium on Foundations of Probability and Statistics and Statistical Theories of Science,* University of Western Ontario, Canada, May 1973.

	90% point (10% in lower tail)	10% point (10% in upper tail)
"Consensus"	R_L = 0.843 (Example 2)	R_U = 0.965 (Example 5)
Bayesian approach	R_L = 0.846	R_U = 0.963

The differences increase as the number of tests decrease.

To find the proper Bayesian curve for any of the applications of Examples 1-5, add one to S and N and proceed as shown in the examples. Graphs are provided up to N = 101, so the Bayesian approach may be performed on tests of up to 100 items.

THEORY

Consider the determination of an unknown population reliability (R), based on the testing of a sample of N items randomly drawn from the population. The probability (B(j)) of obtaining exactly j successes within the N items tested is given by the binomial distribution

$$B(j) = \frac{N!}{j!(N-j)!}R^j(1 - R)^{N-j} \tag{1}$$

The probability of obtaining, at most, S - 1 successes in the sample of N is $\sum_{j=0}^{S-1} B(j)$. This probability is used as the definition of the confidence level that the reliability is at least R_L, given S and N.

$$\frac{1}{100} C_L = \sum_{j=0}^{S-1} B(j) = 1 - \sum_{j=S}^{N} B(j) \tag{2}$$

Conversely, the confidence level that the reliability is at most R_U, given S and N is defined by

$$\frac{1}{100} C_U = \sum_{j=S+1}^{N} B(j) = 1 - \sum_{j=0}^{S} B(j) \tag{3}$$

To avoid numerical pitfalls, the binomial probability function B(j) was evaluated via the evidence function.

$$E(j) = j\ln(R/f) + (N - j) \ln [(1 - R)/(1 - f)] \tag{4}$$

where f = j/N

The value of B(j) is then found by

$$B(j) = \frac{G(N)}{G(j)\ G(N - j)} e^{-E} \tag{5}$$

where

$$G(1) = 1 \tag{6}$$

$$G(j) = j!(e/j)^j \quad 2 \leq j \leq 14 \tag{7}$$

$$G(j) = \left(1 + \frac{1}{12j - 1}\right)\sqrt{2\pi j} \quad 15 \leq j \leq \infty \tag{8}$$

When j is greater than 14, Stirlings second order approximation to the factorial is used (this yields at least five place accuracy in this range). At values up to 14, the exact factorial expression is used.

This is not the only way in which the graphical values could have been computed. For instance, Thorne (footnote 1) observes that Eq. (2) is equivalent to

$$\frac{1}{100} C = \frac{N!}{(S - 1)!\ (N - S)!} \int_R^1 R^{(S-1)} (1 - R)^{[(N-1) - (S-1)]} dR \tag{9}$$

Equation (9) is of more than academic interest. It happens that this is the correct Bayesian estimate of confidence for (S - 1) successes in a sample size of (N - 1). Therefore, by suitably choosing N and S, either the Bayesian or the consensus approach is possible using the graphs of this report.

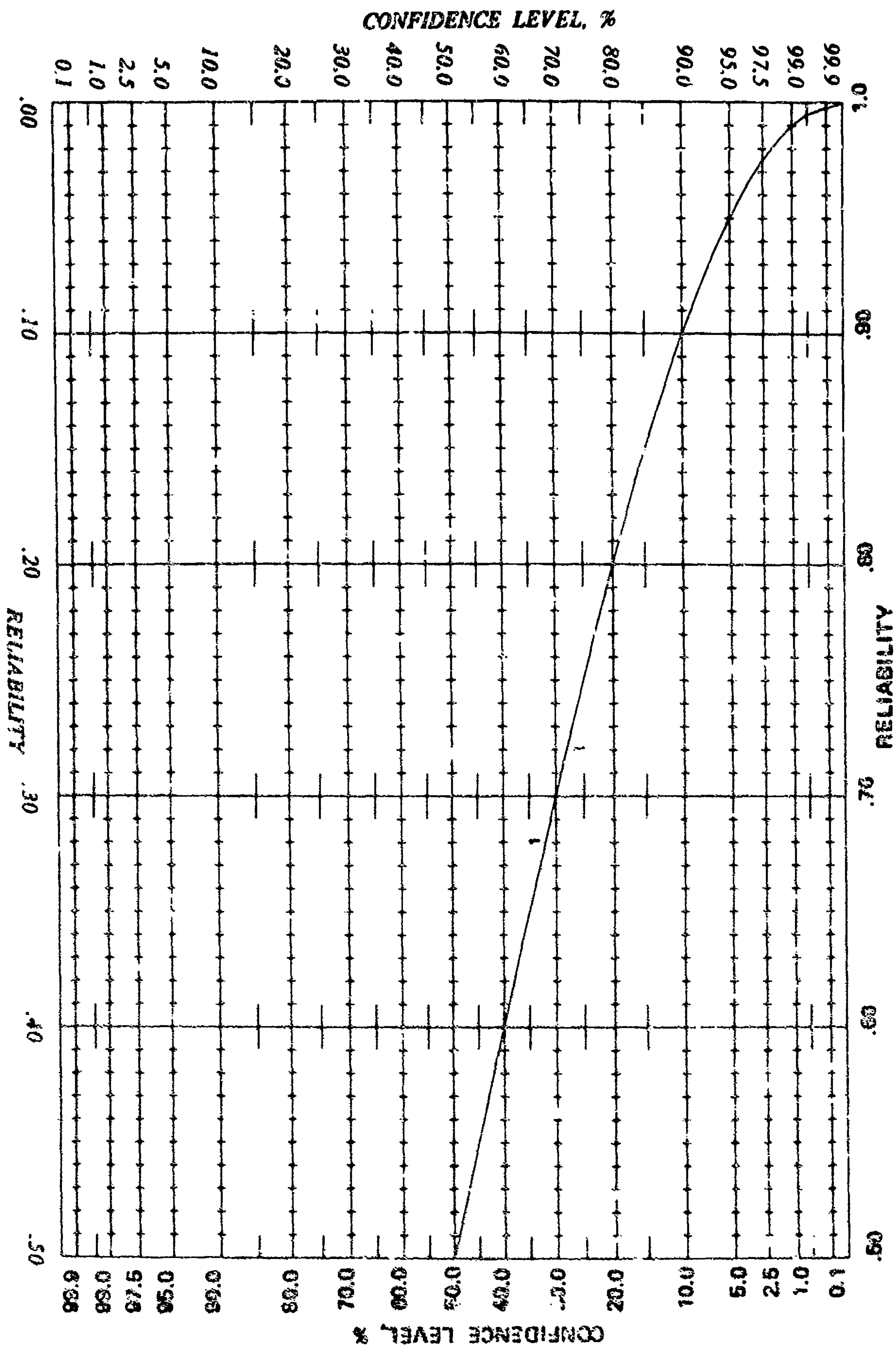

FIGURE 1. Confidence Level and Reliability for N = 1.

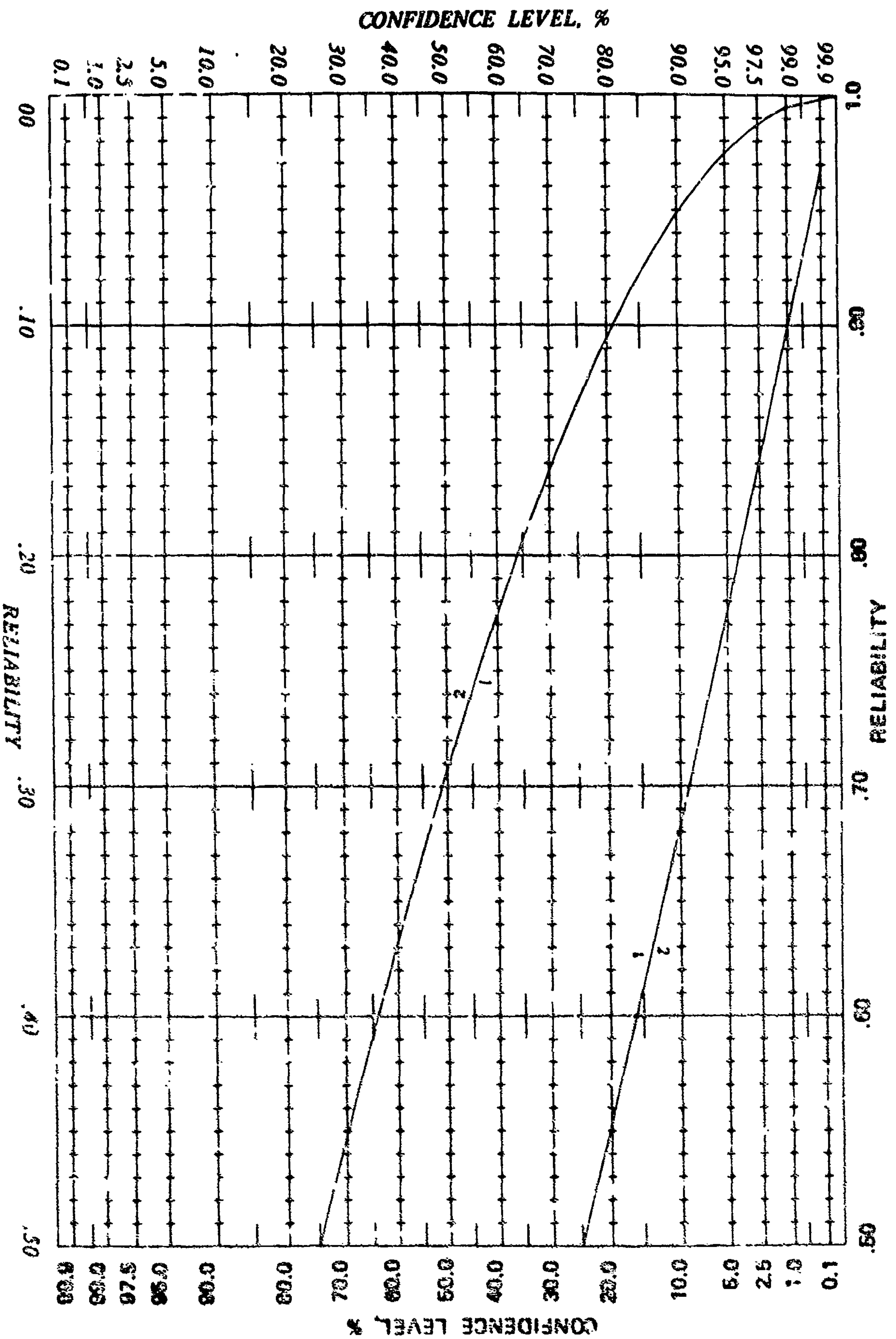

FIGURE 2. Confidence Level and Reliability for N = 2.

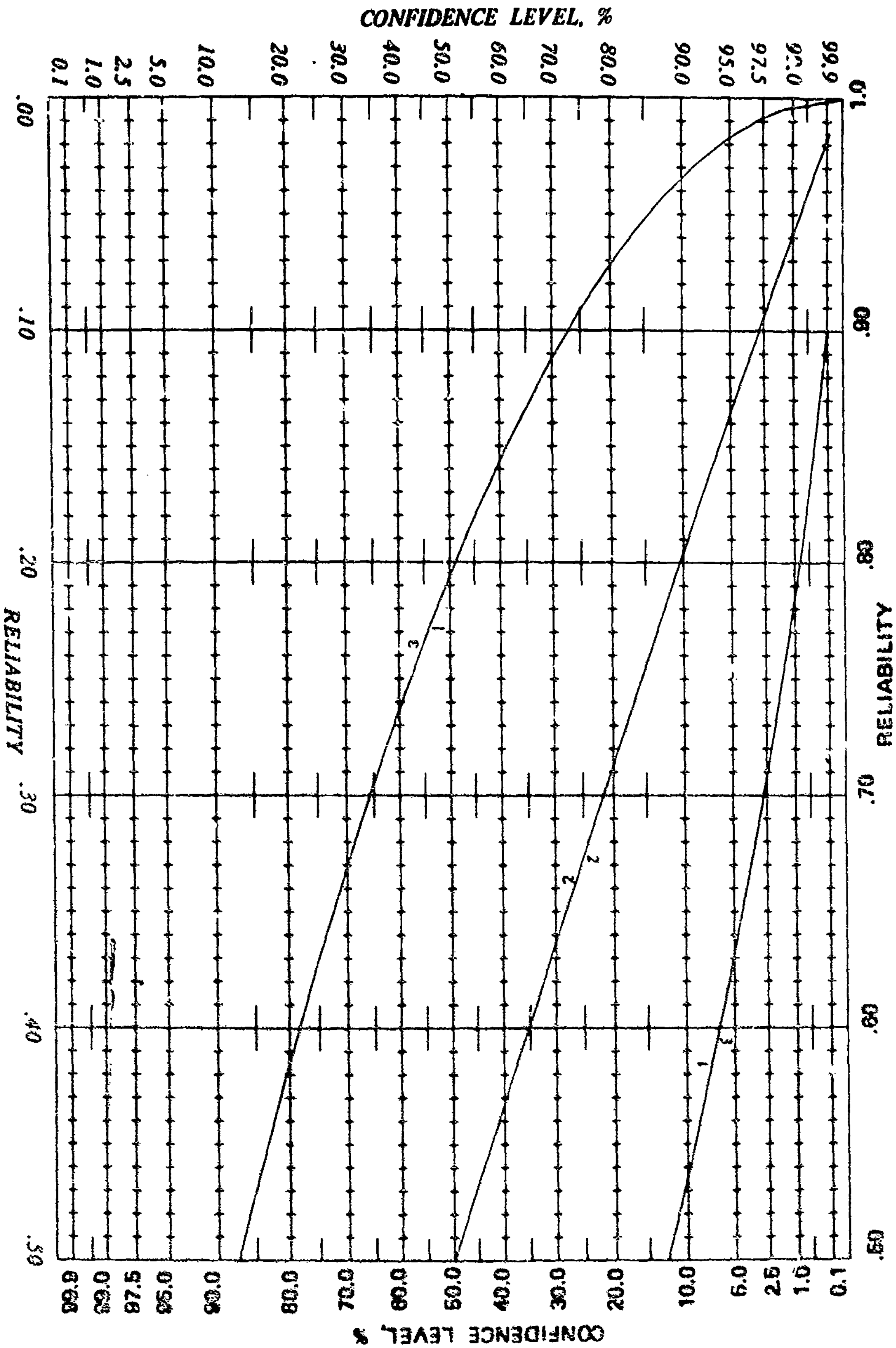

FIGURE 3. Confidence Level and Reliability for N = 3.

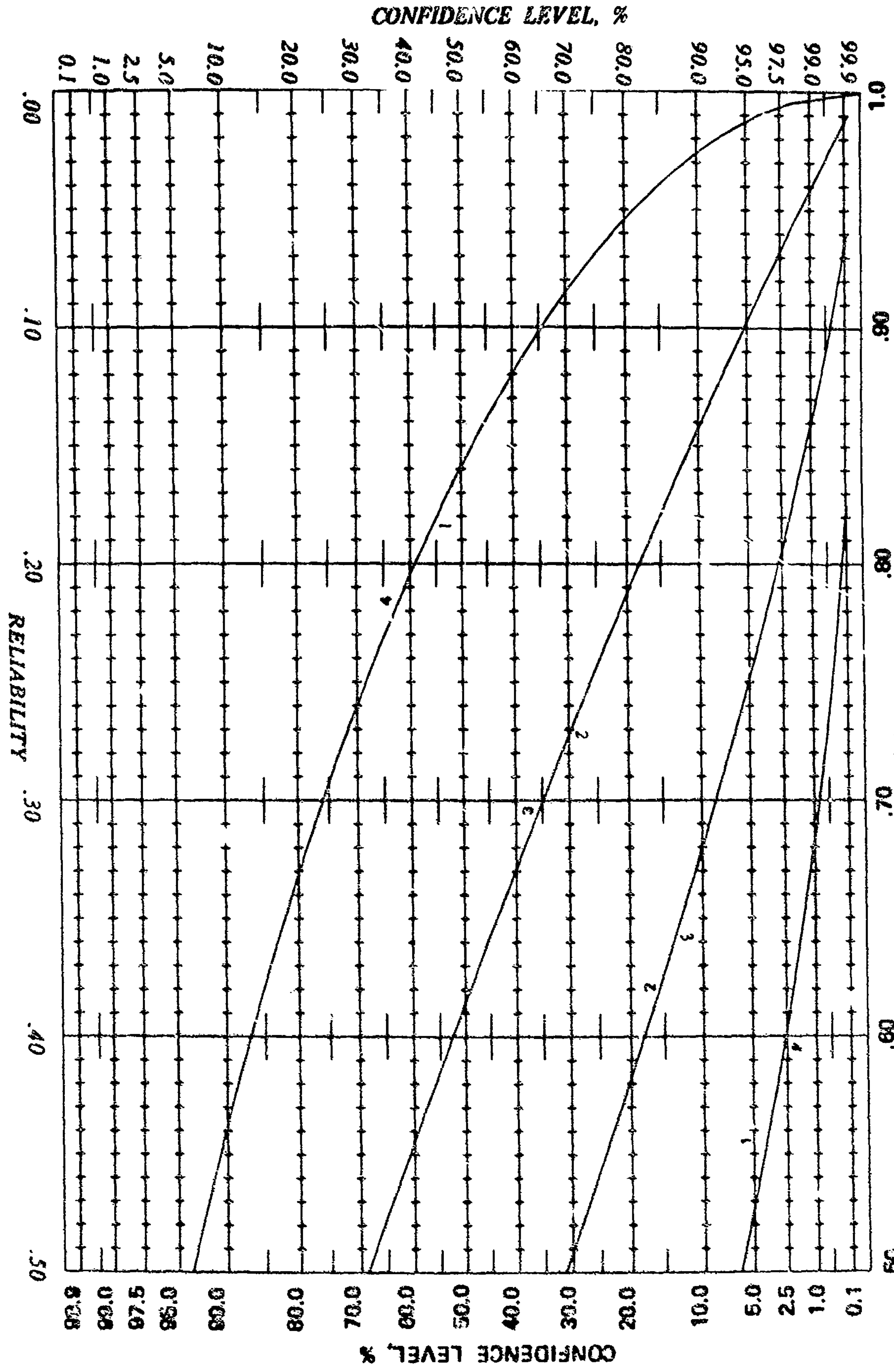

FIGURE 4. Confidence Level and Reliability for N = 4.

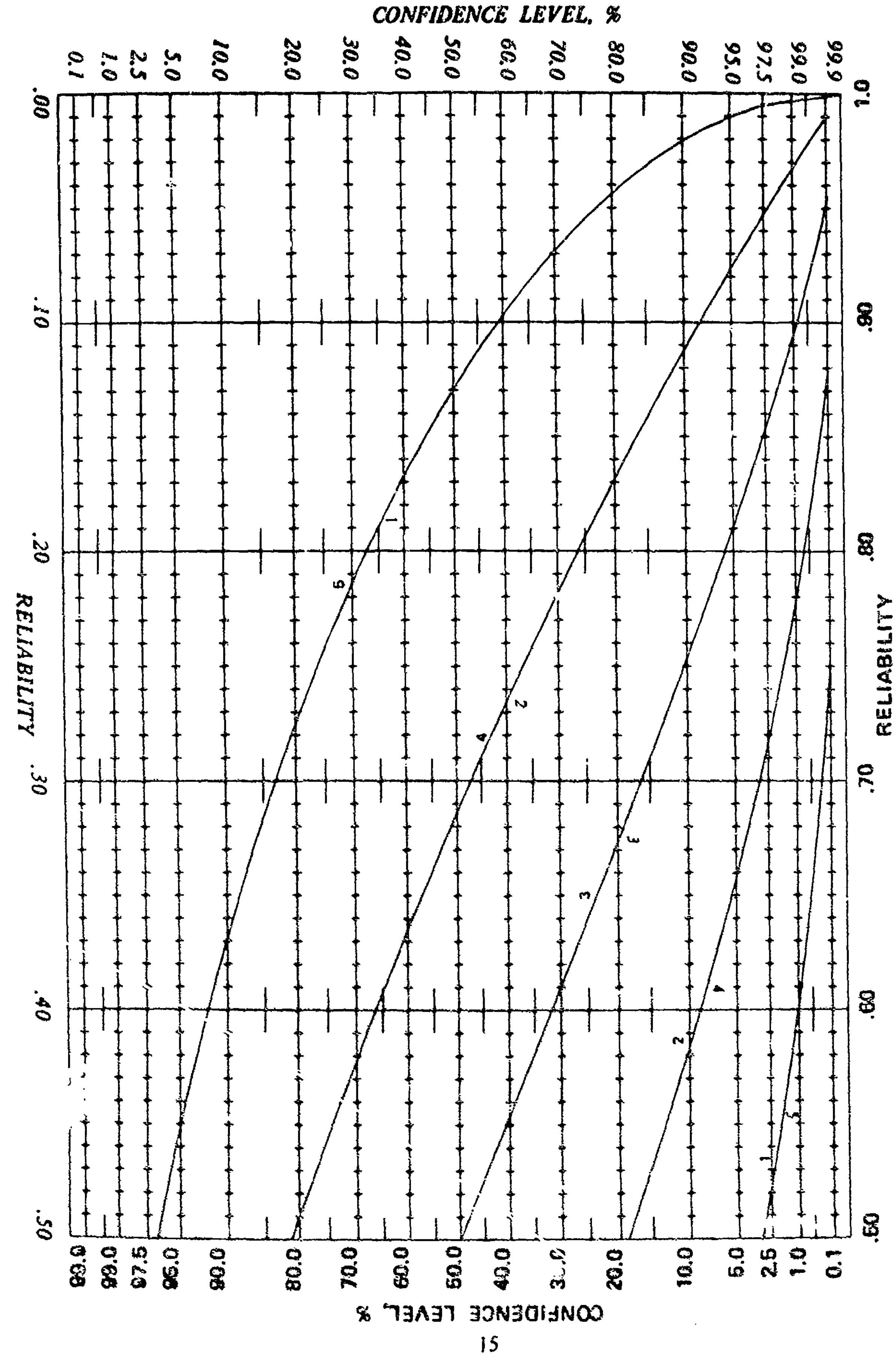

FIGURE 5. Confidence Level and Reliability for N = 5.

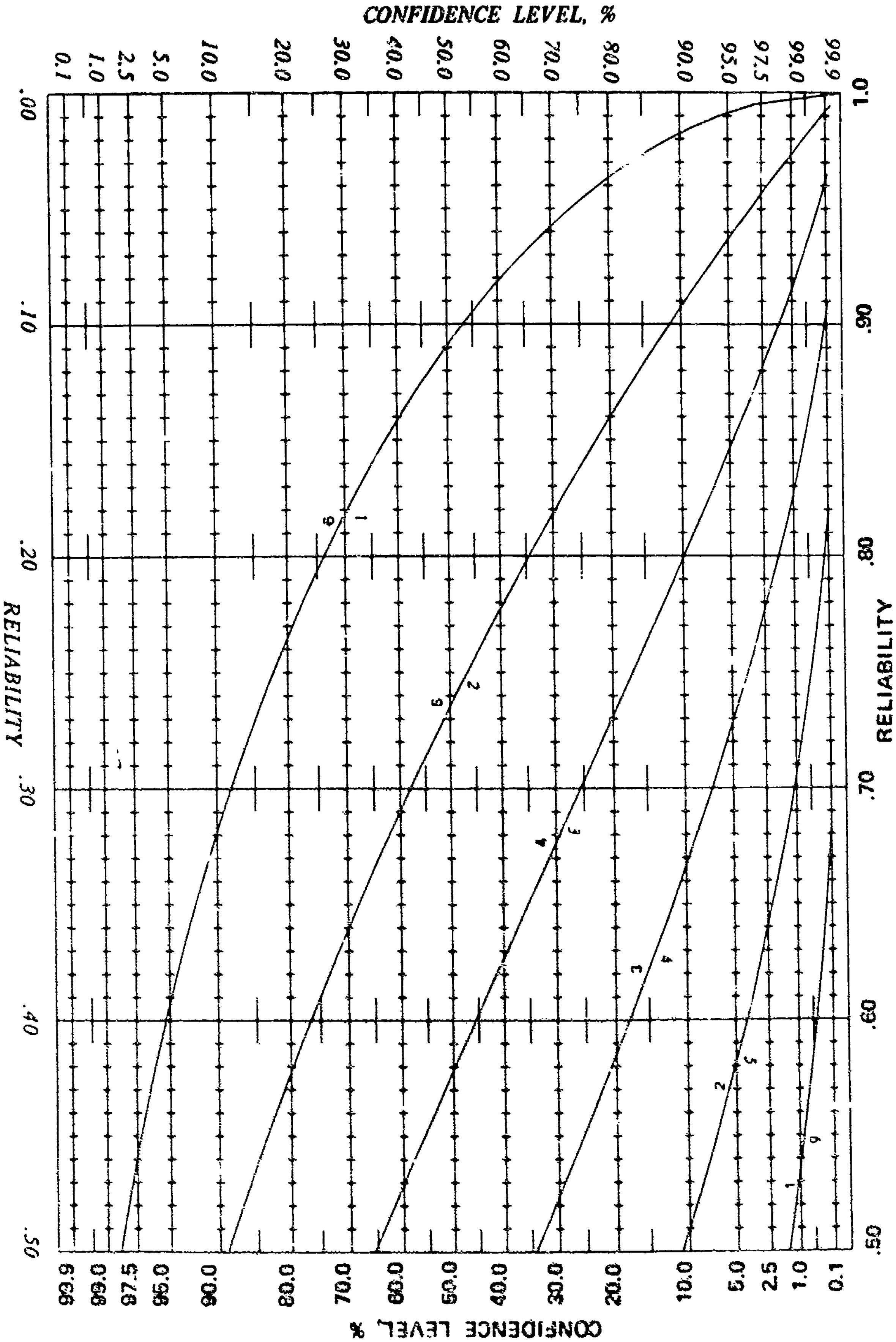

FIGURE 6. Confidence Level and Reliability for N = 6.

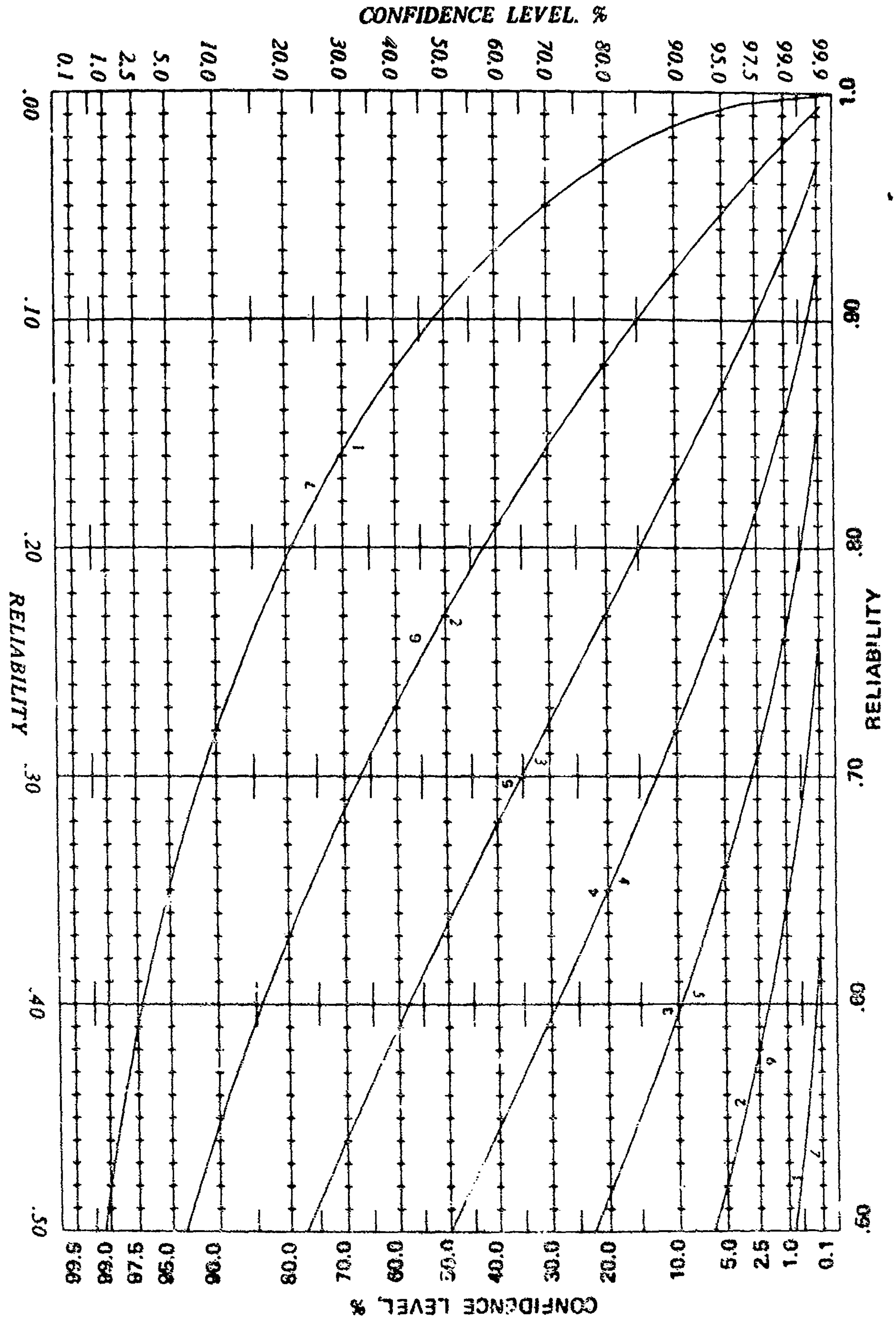

FIGURE 7. Confidence Level and Reliability for N = 7.

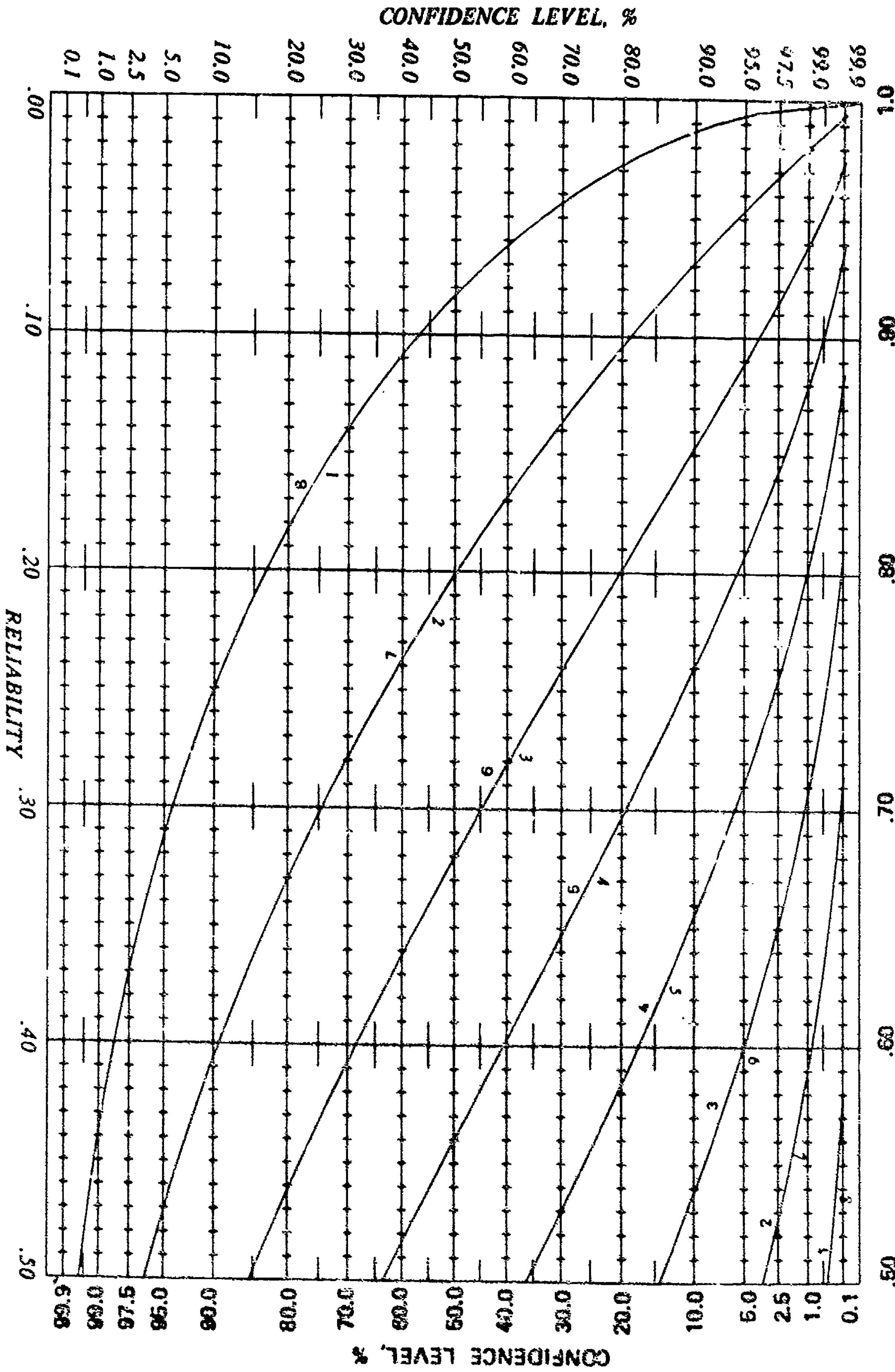

FIGURE 8. Confidence Level and Reliability for N = 8.

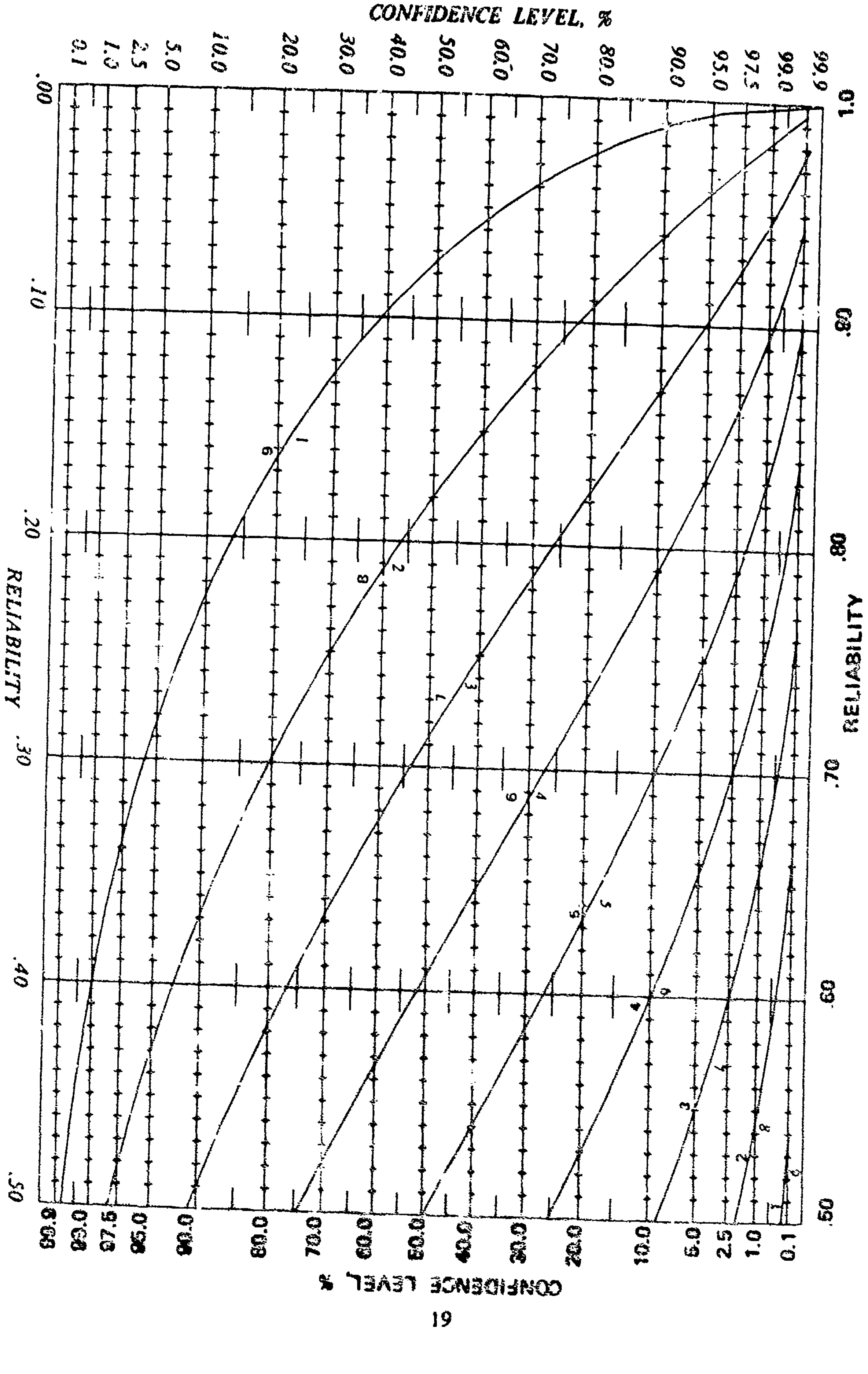

FIGURE 9. Confidence Level and Reliability for N = 9.

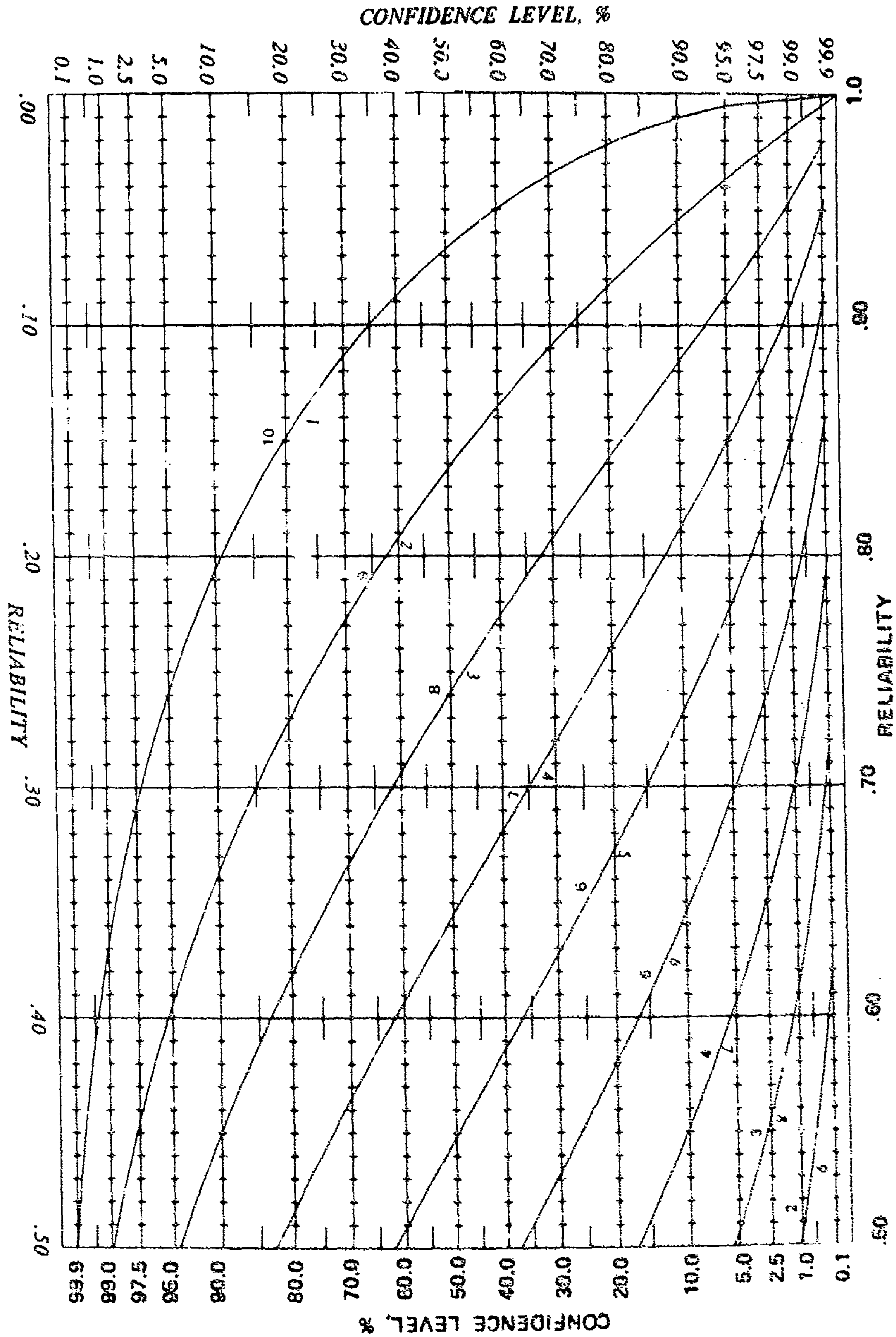

FIGURE 10. Confidence Level and Reliability for N = 10.

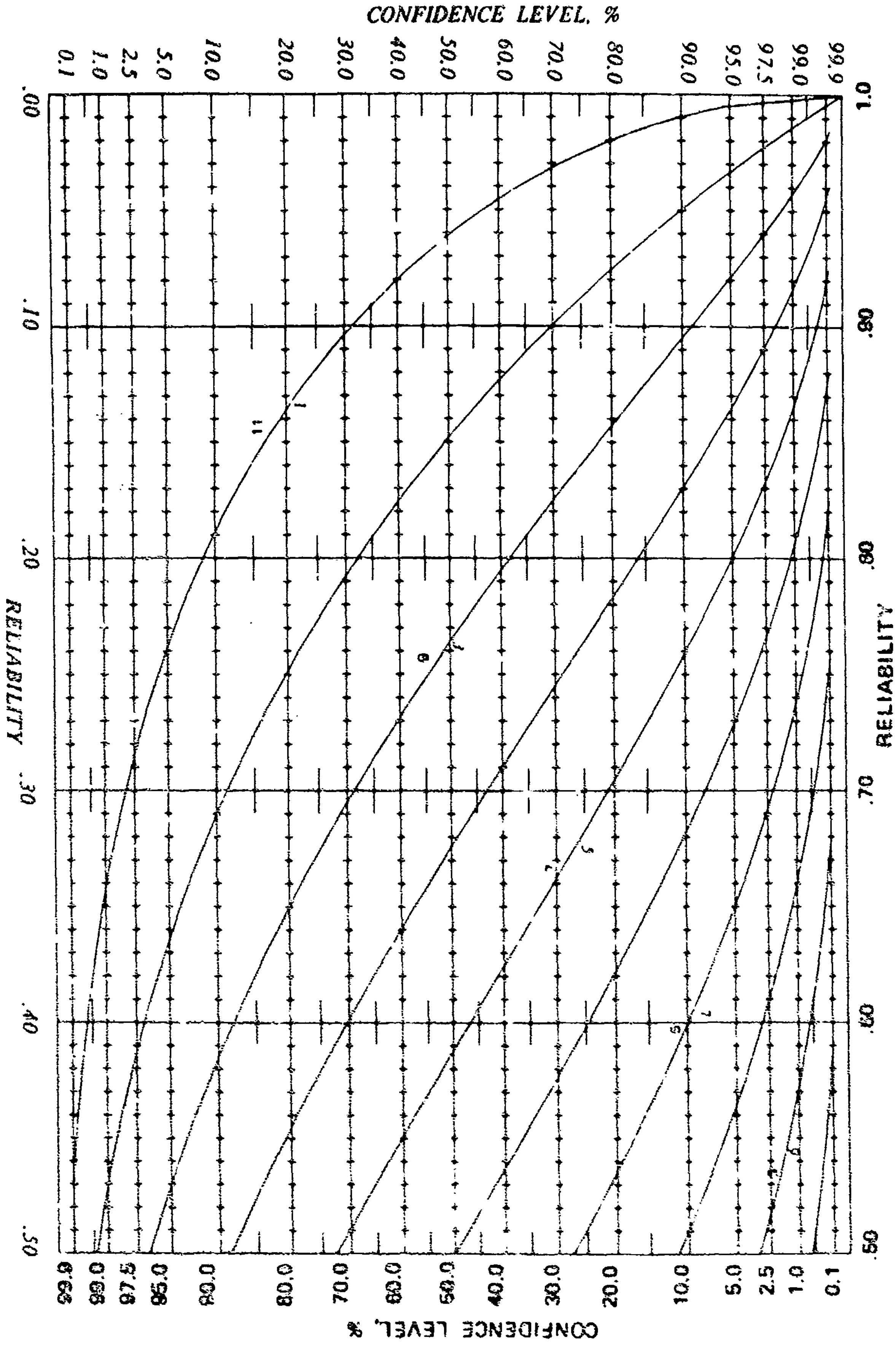

FIGURE 11. Confidence Level and Reliability for N = 11.

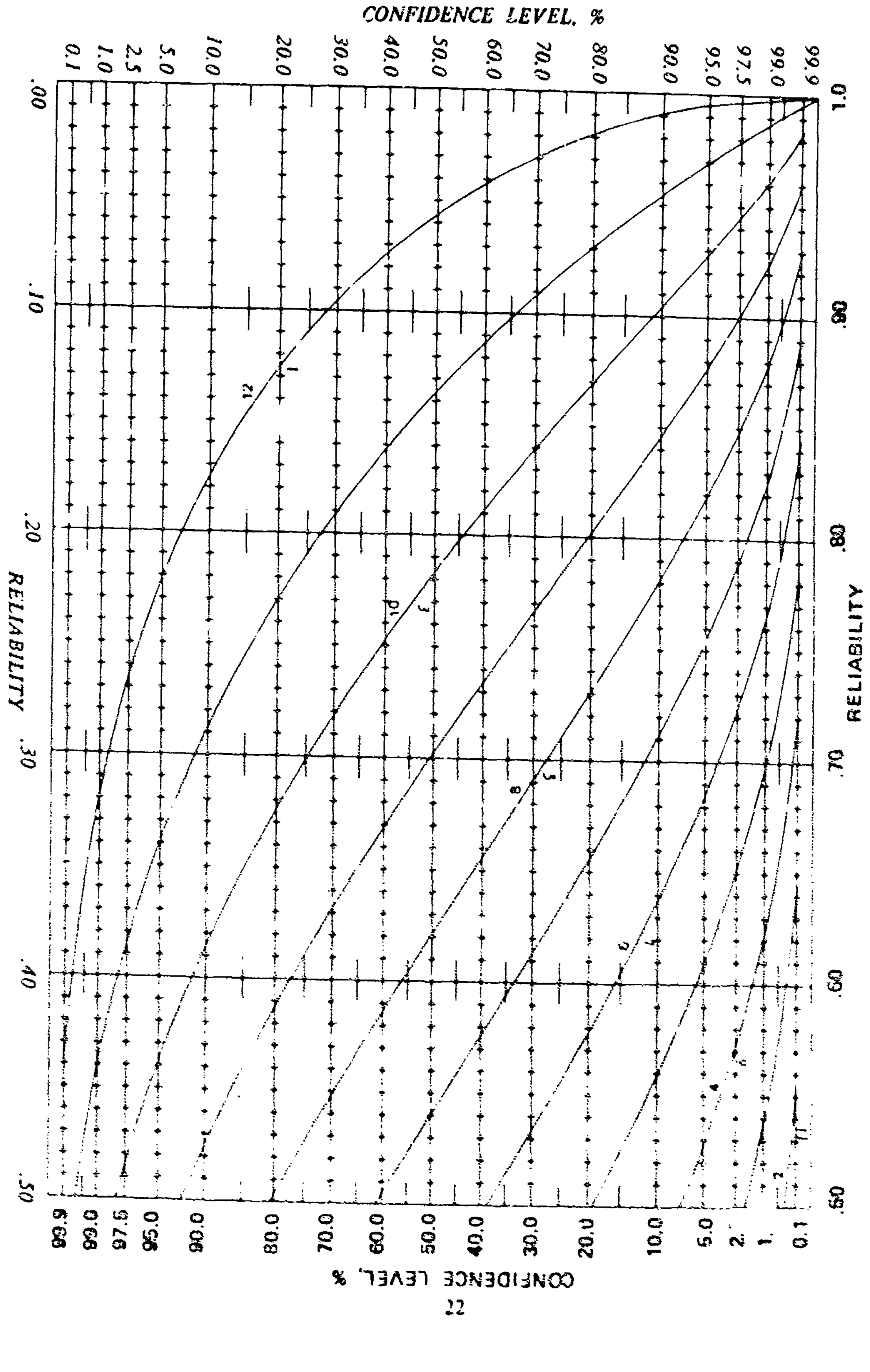

FIGURE 12. Confidence Level and Reliability for N = 12.

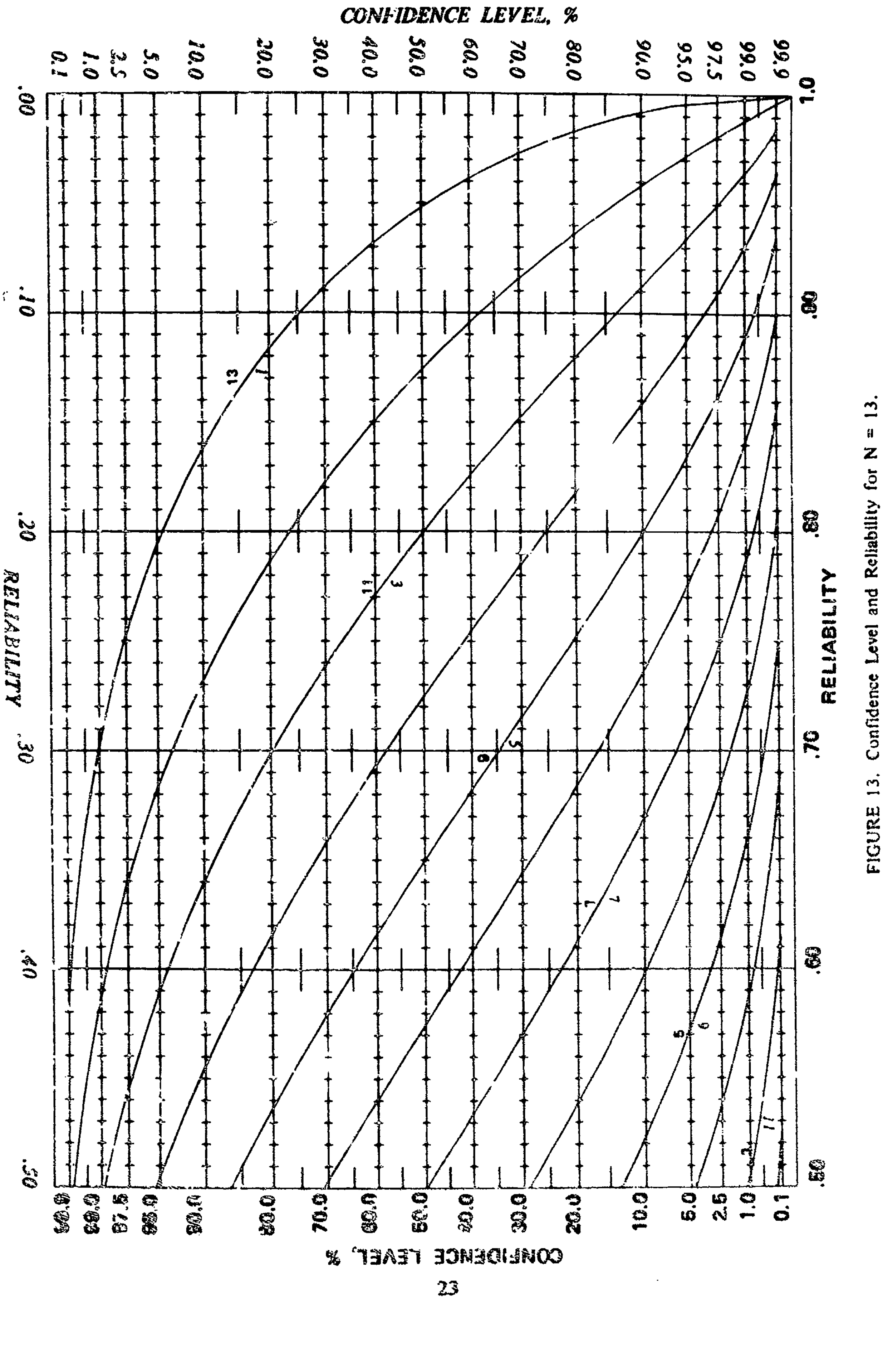

FIGURE 13. Confidence Level and Reliability for N = 13.

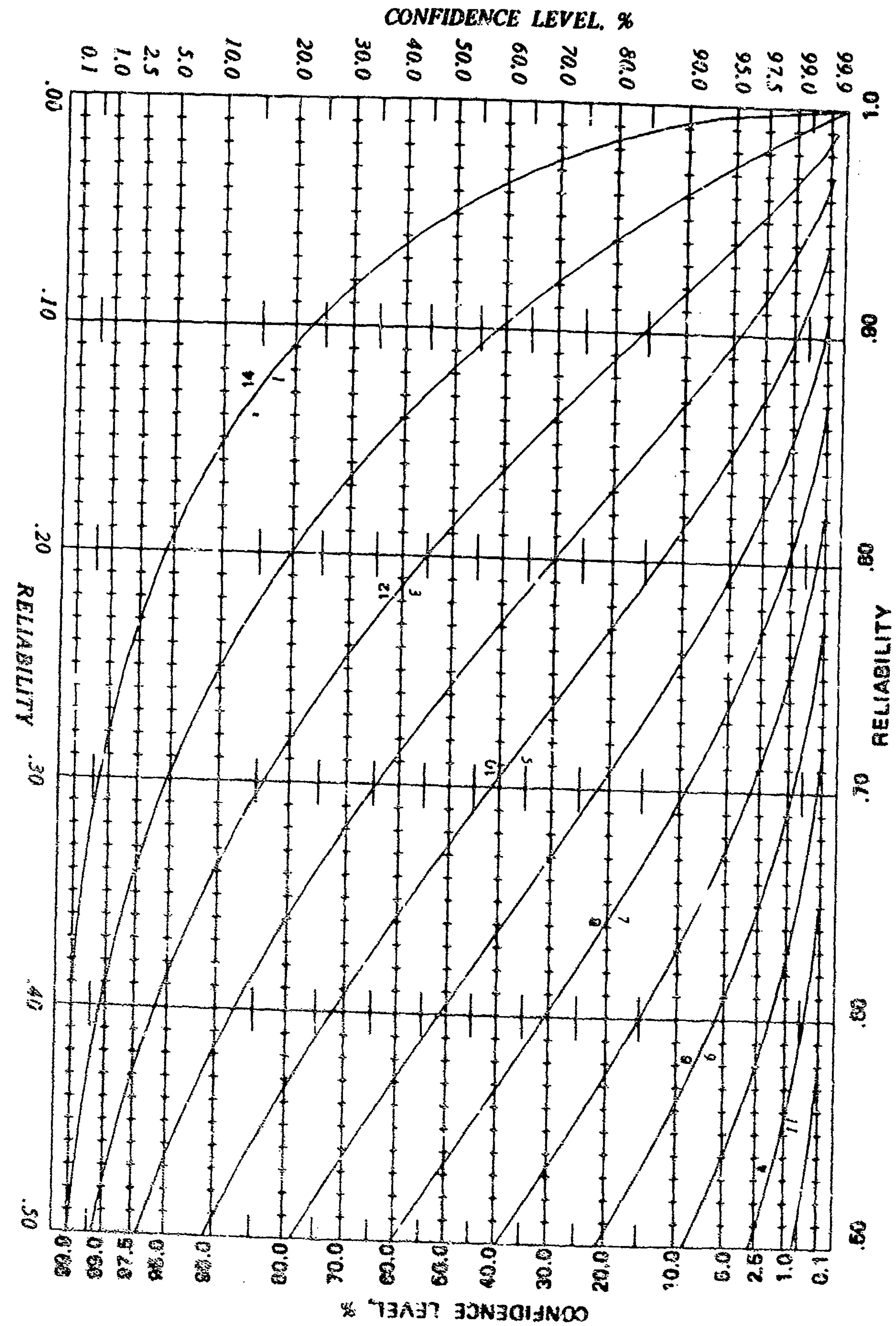

FIGURE 14. Confidence Level and Reliability for N = 14.

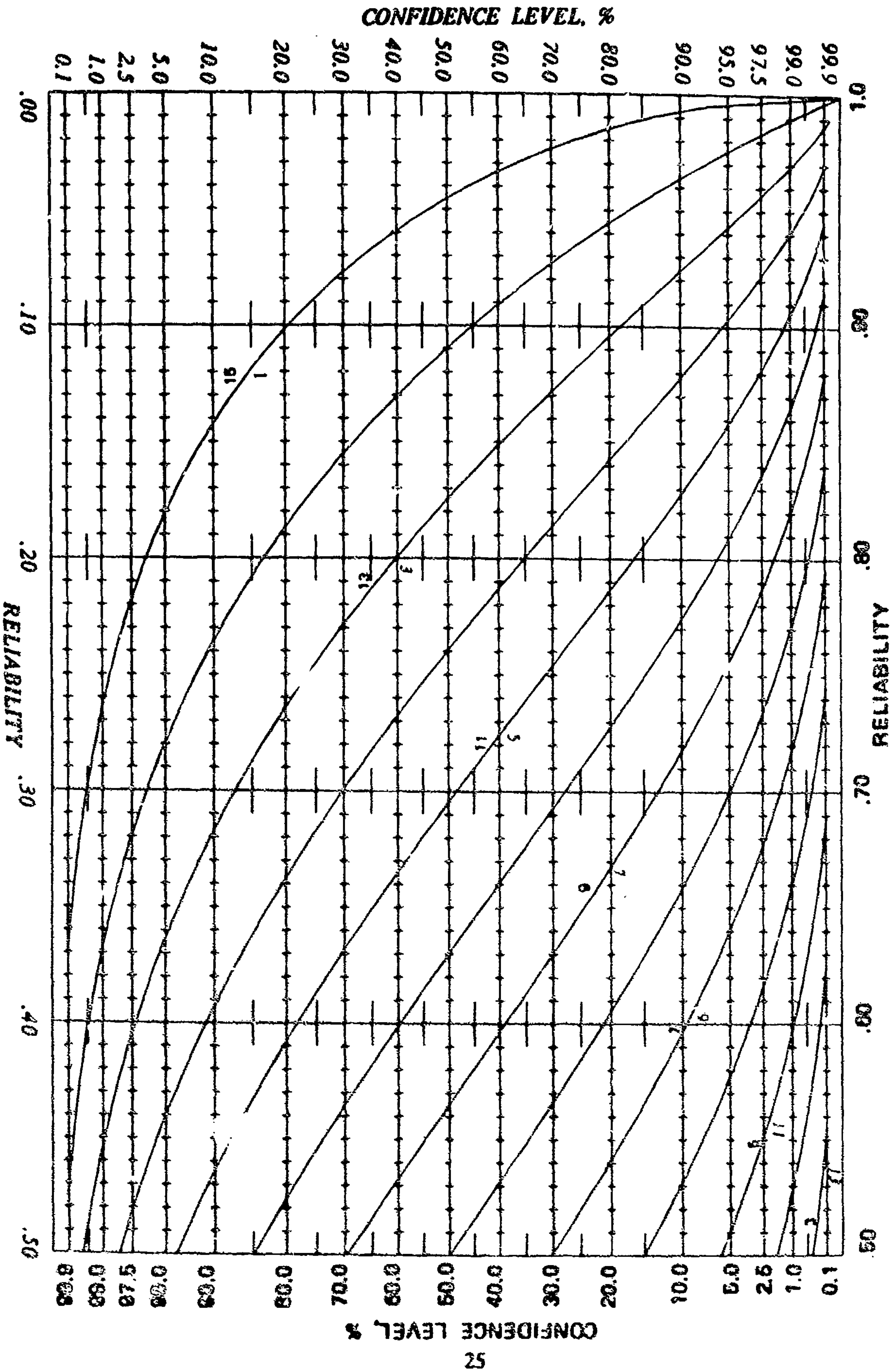

FIGURE 15. Confidence Level and Reliability for N = 15.

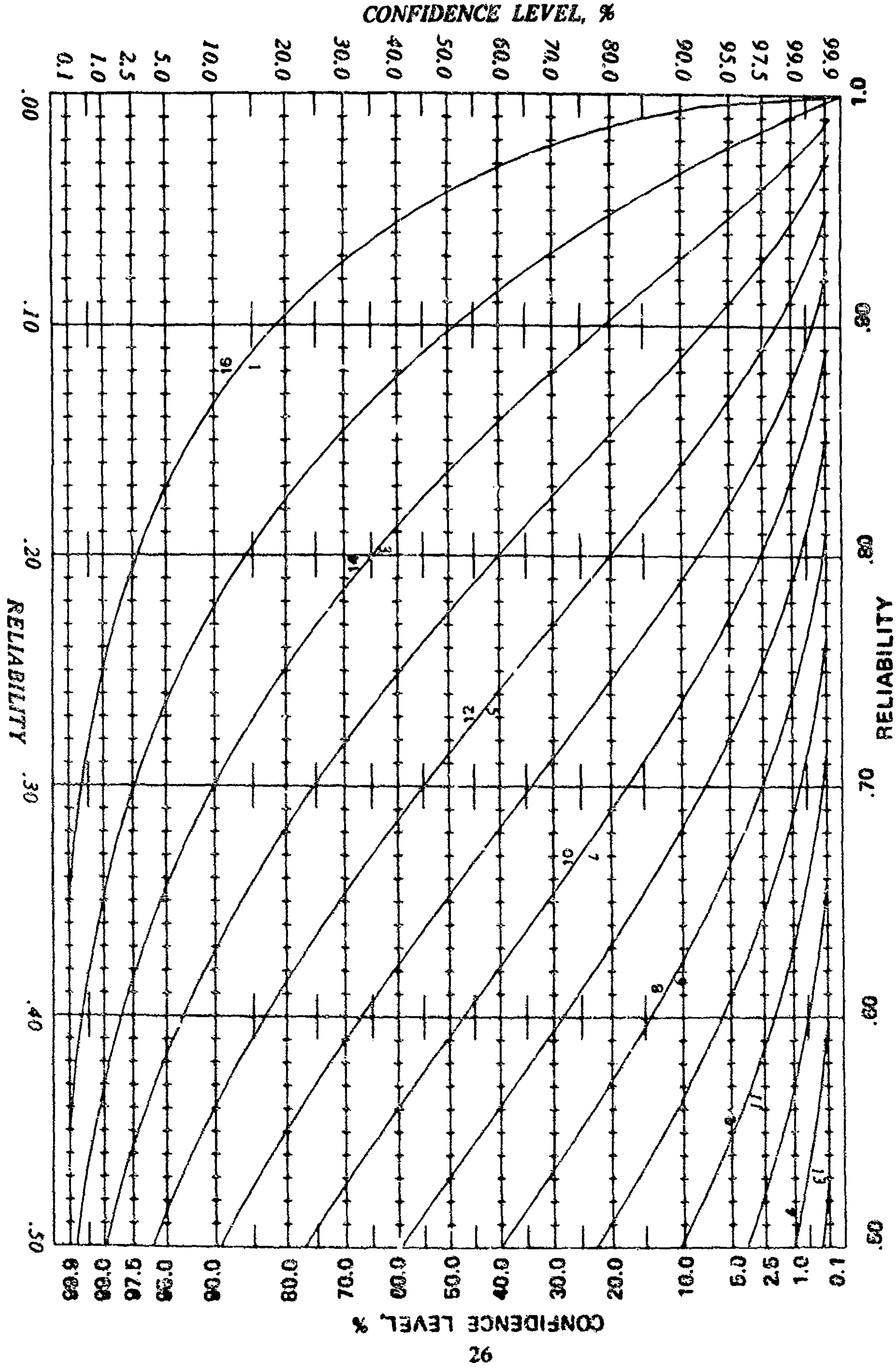

FIGURE 16. Confidence Level and Reliability for N = 16.

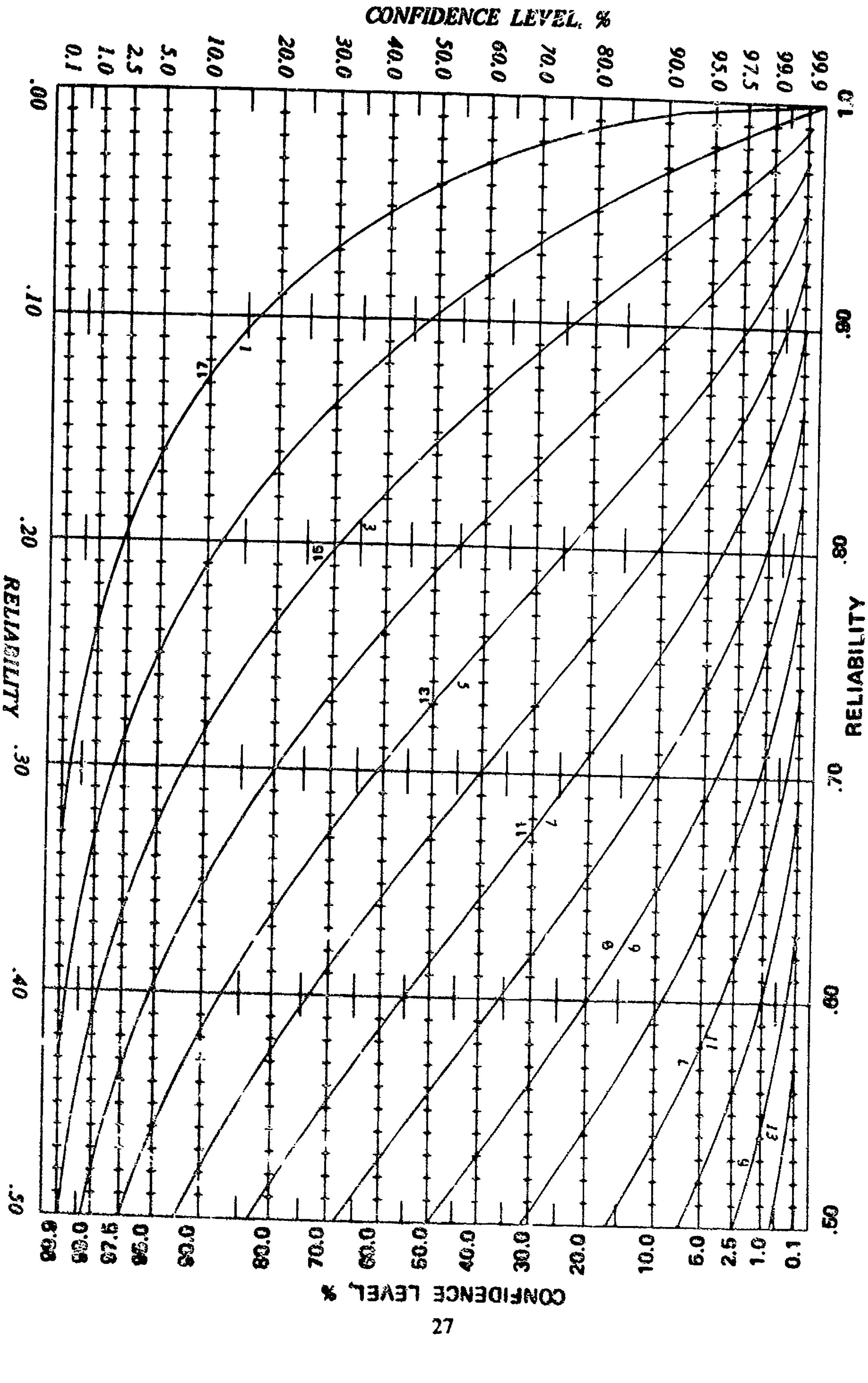

FIGURE 17. Confidence Level and Reliability for N = 17.

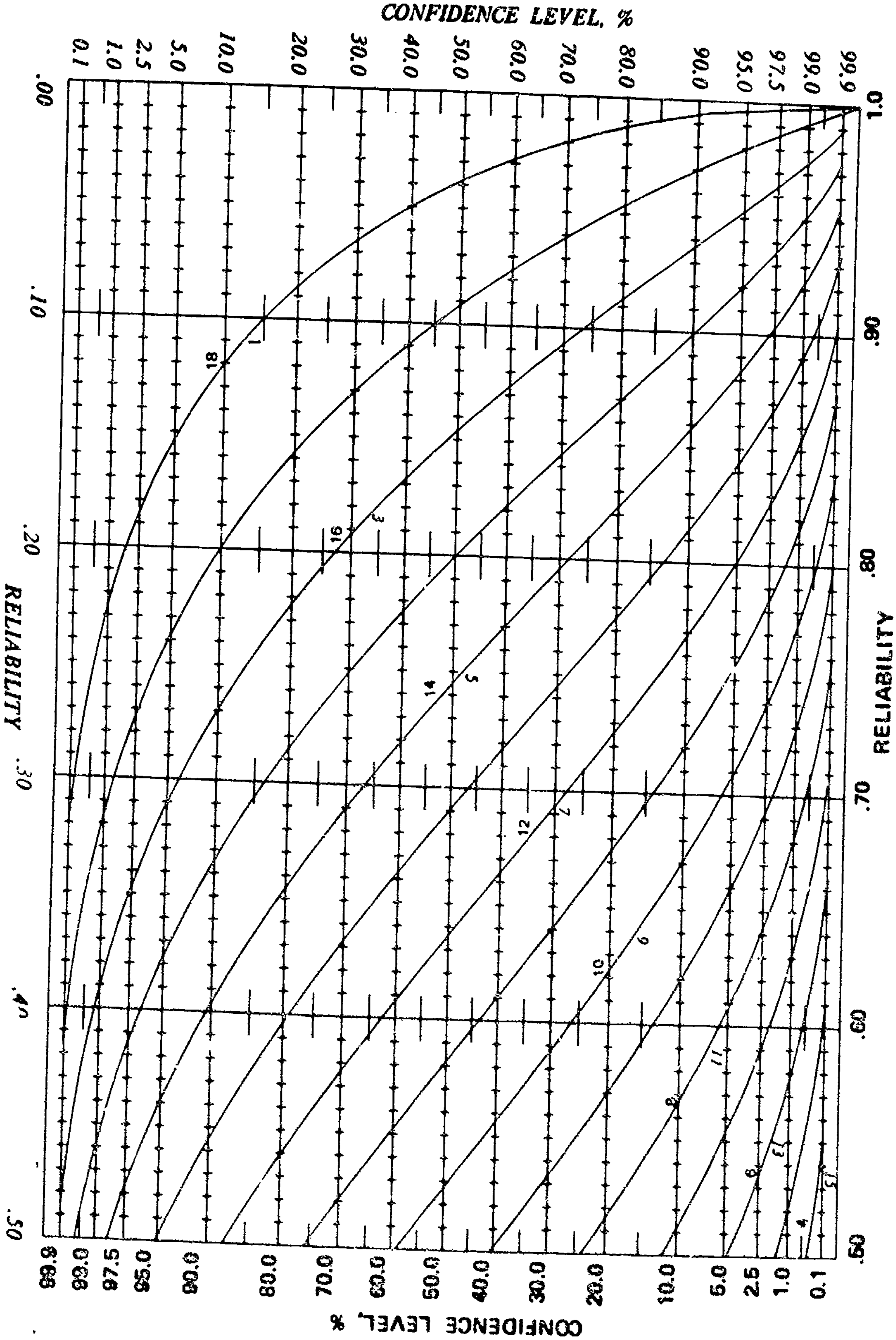

FIGURE 18. Confidence Level and Reliability for N = 18.

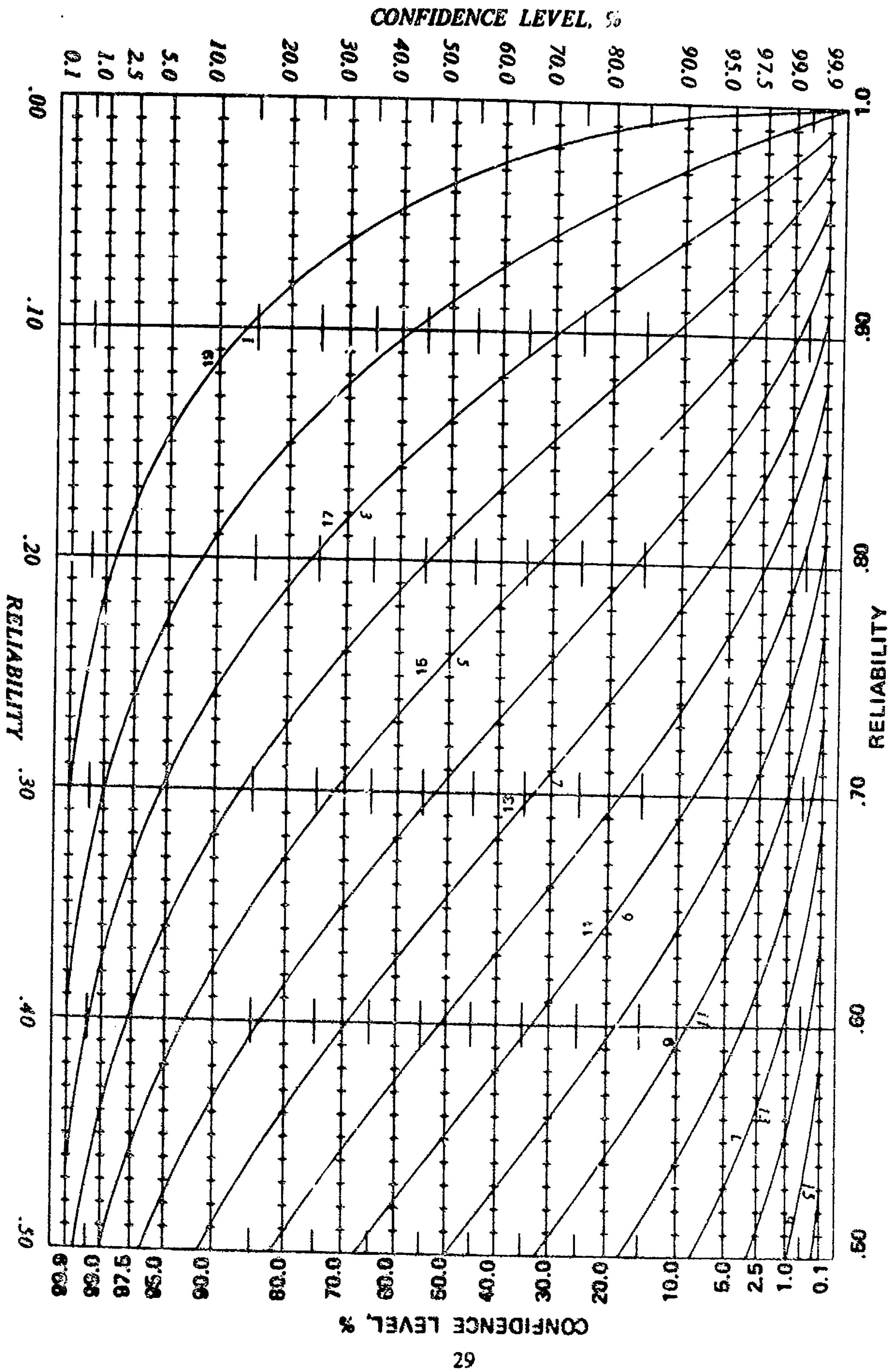

FIGURE 19. Confidence Level and Reliability for N = 19.

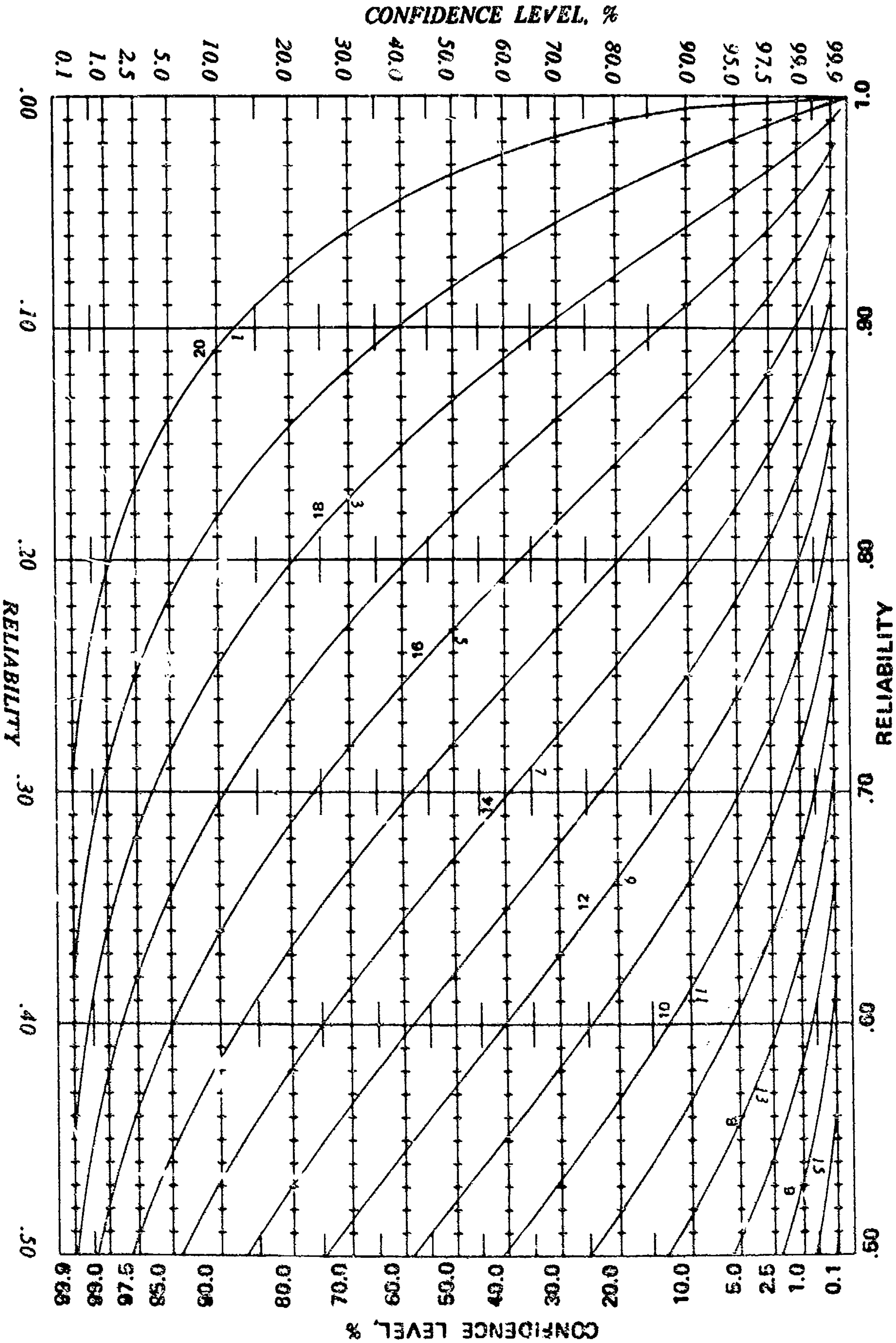

FIGURE 20. Confidence Level and Reliability for N = 20.

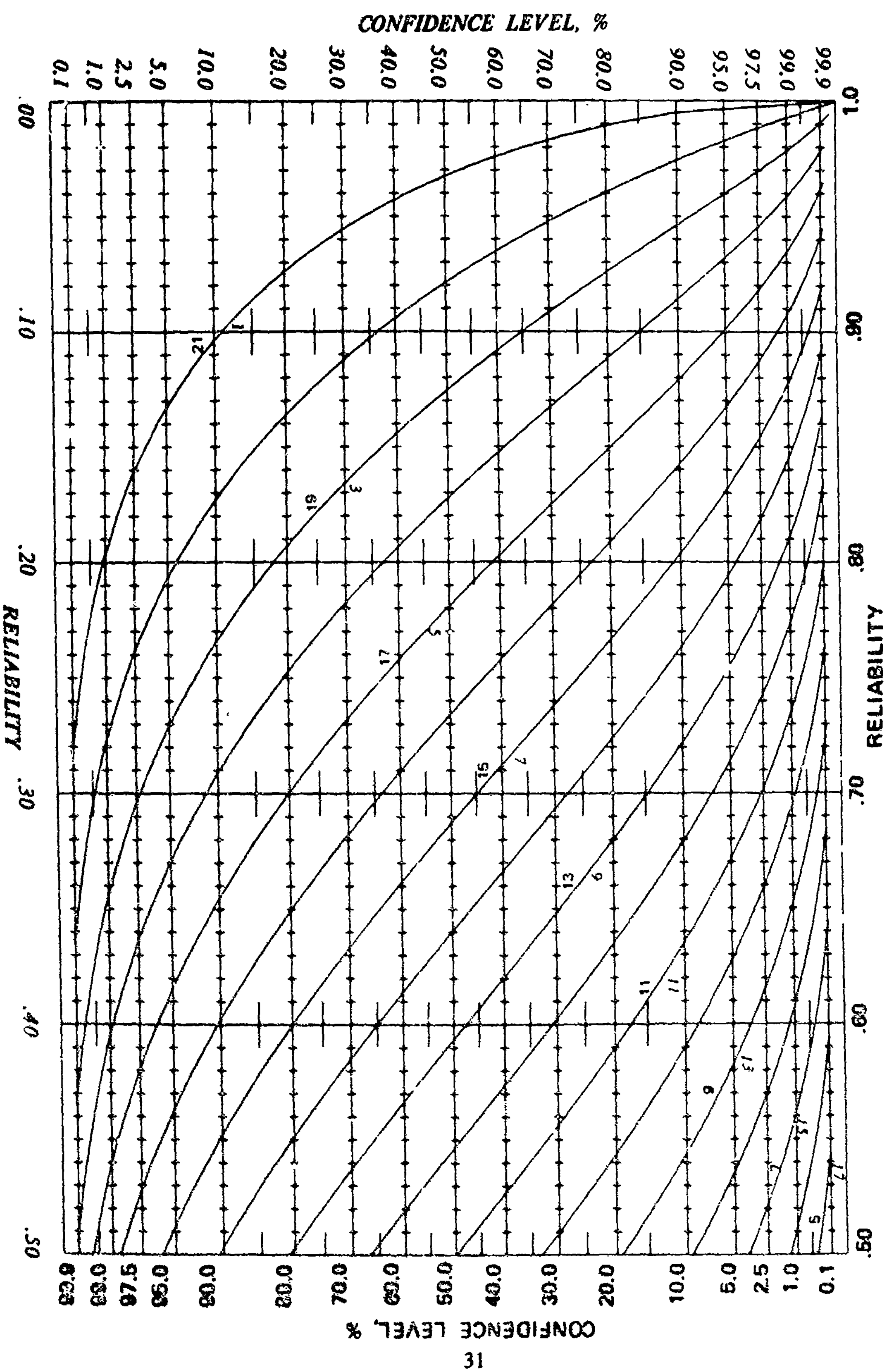

FIGURE 21. Confidence Level and Reliability for N = 21.

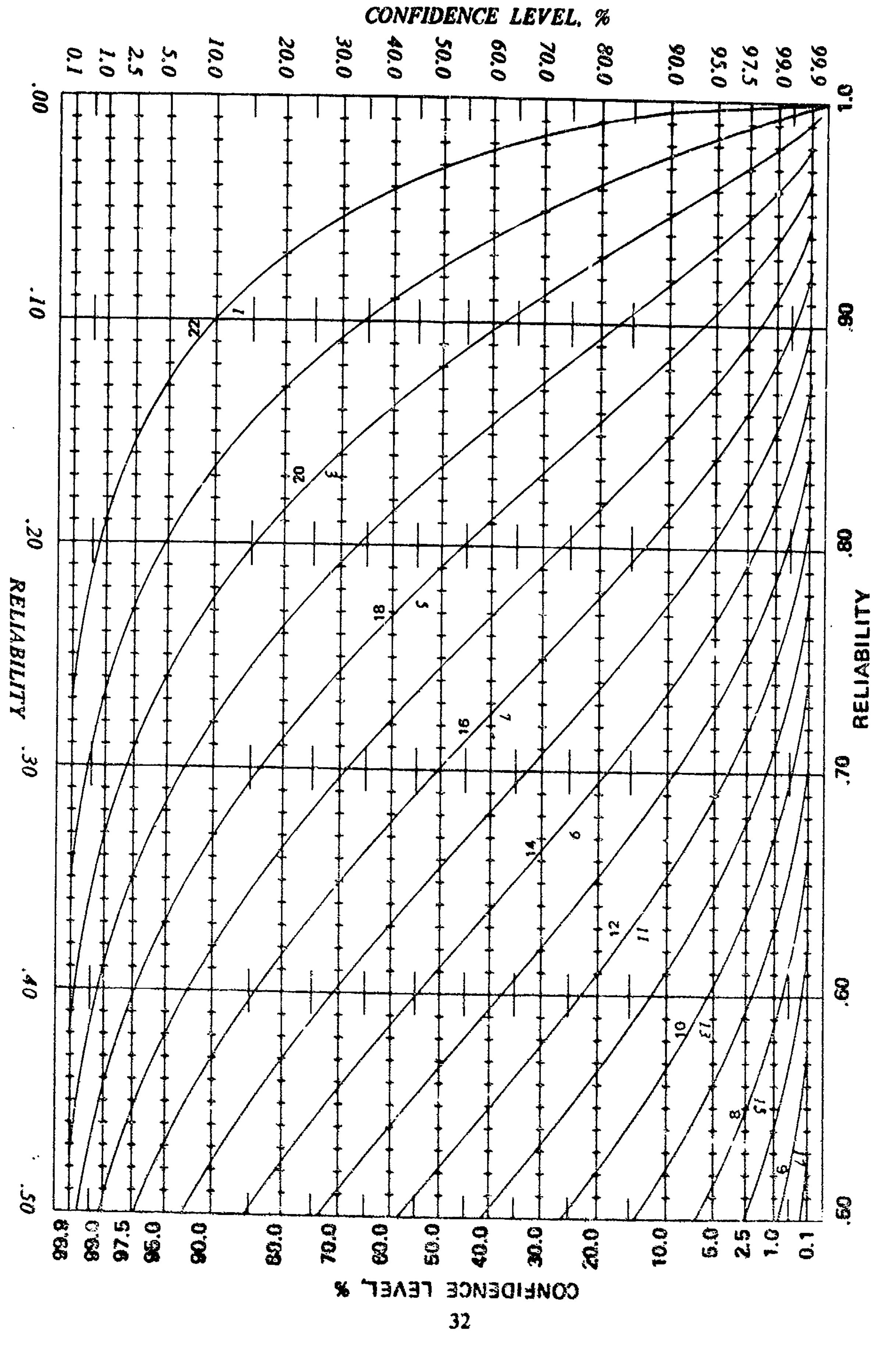

FIGURE 22. Confidence Level and Reliability for N = 22.

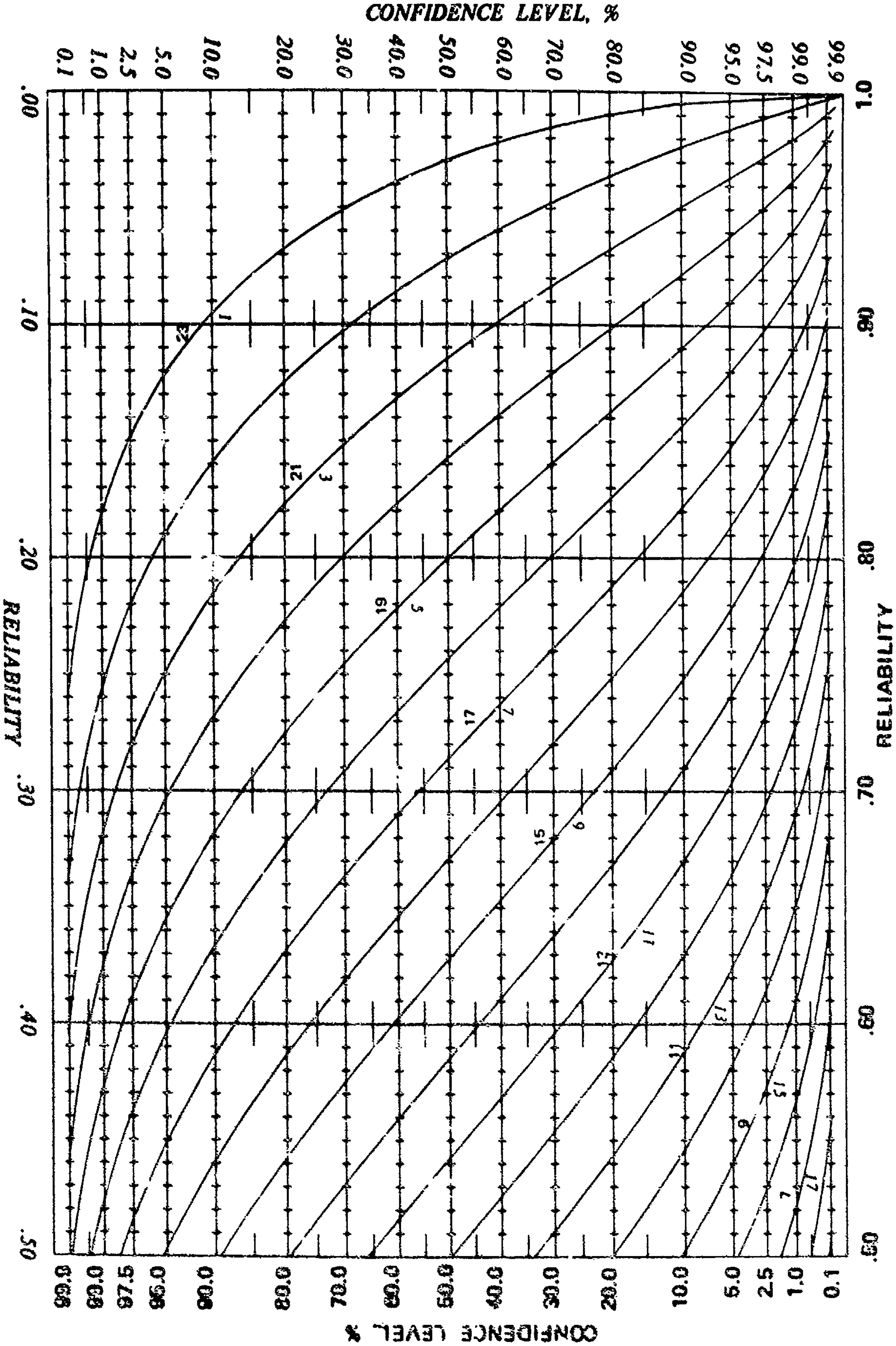

FIGURE 23. Confidence Level and Reliability for N = 23.

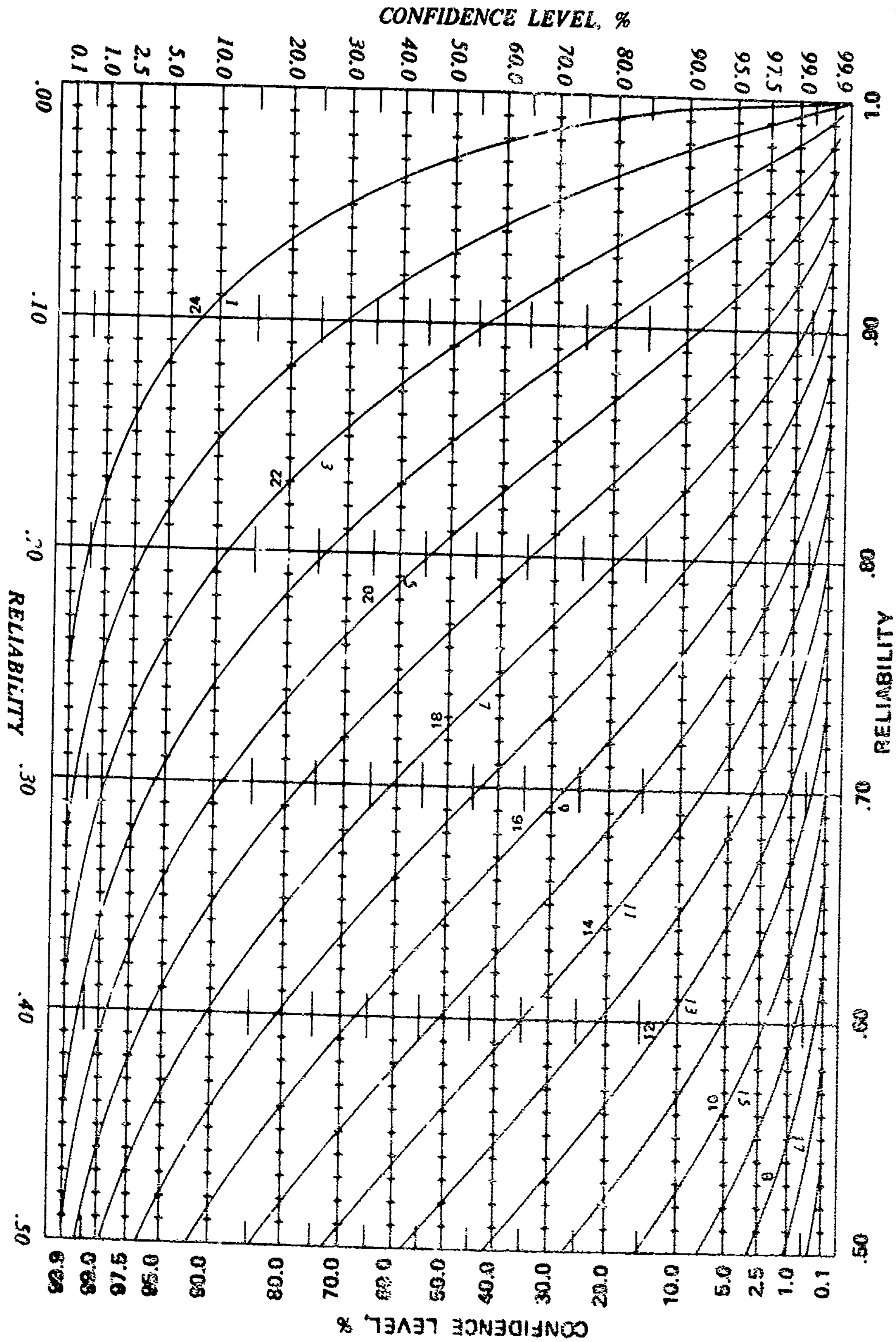

FIGURE 24. Confidence Level and Reliability for N = 24.

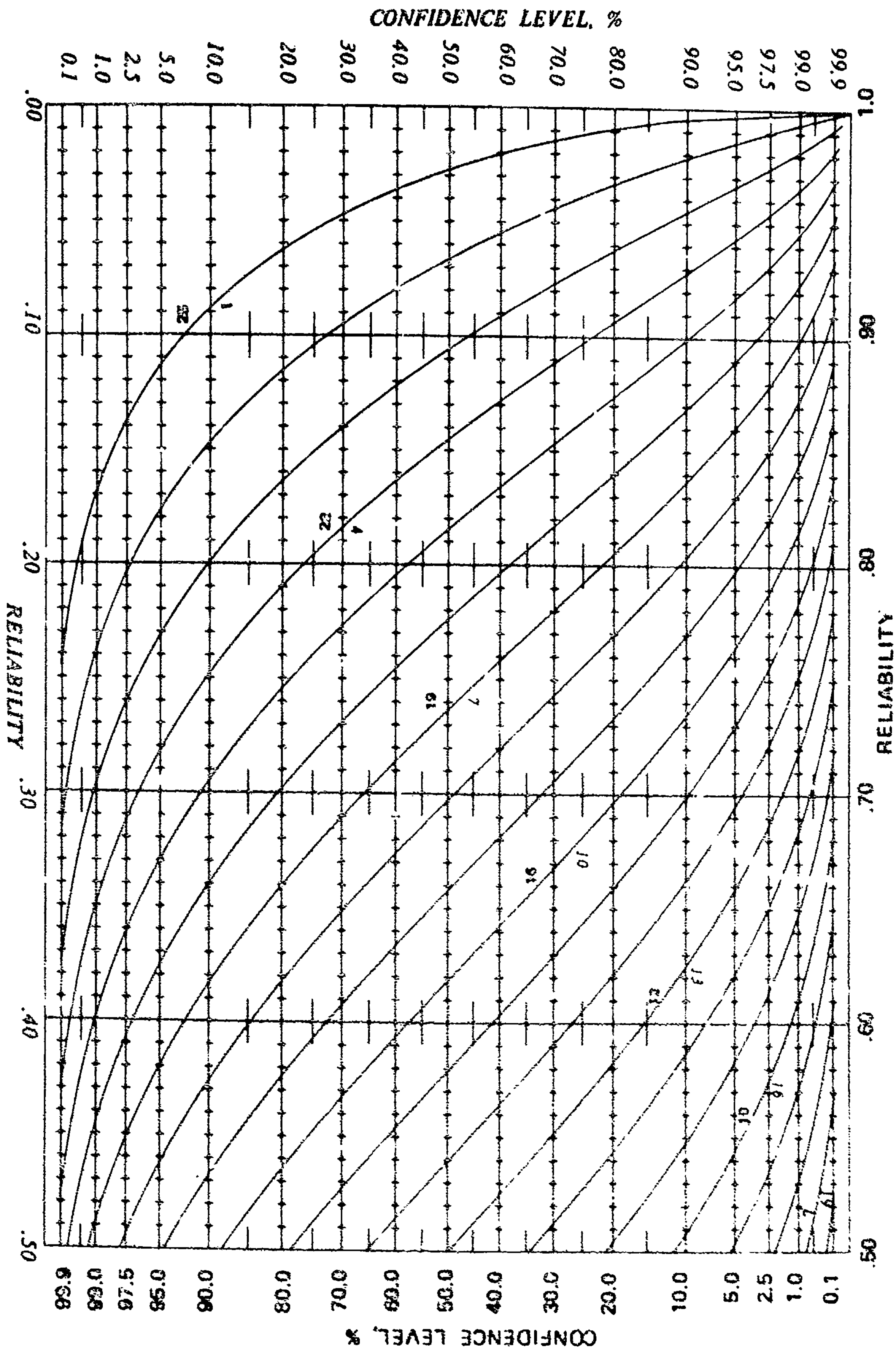

FIGURE 25. Confidence Level and Reliability for N = 25.

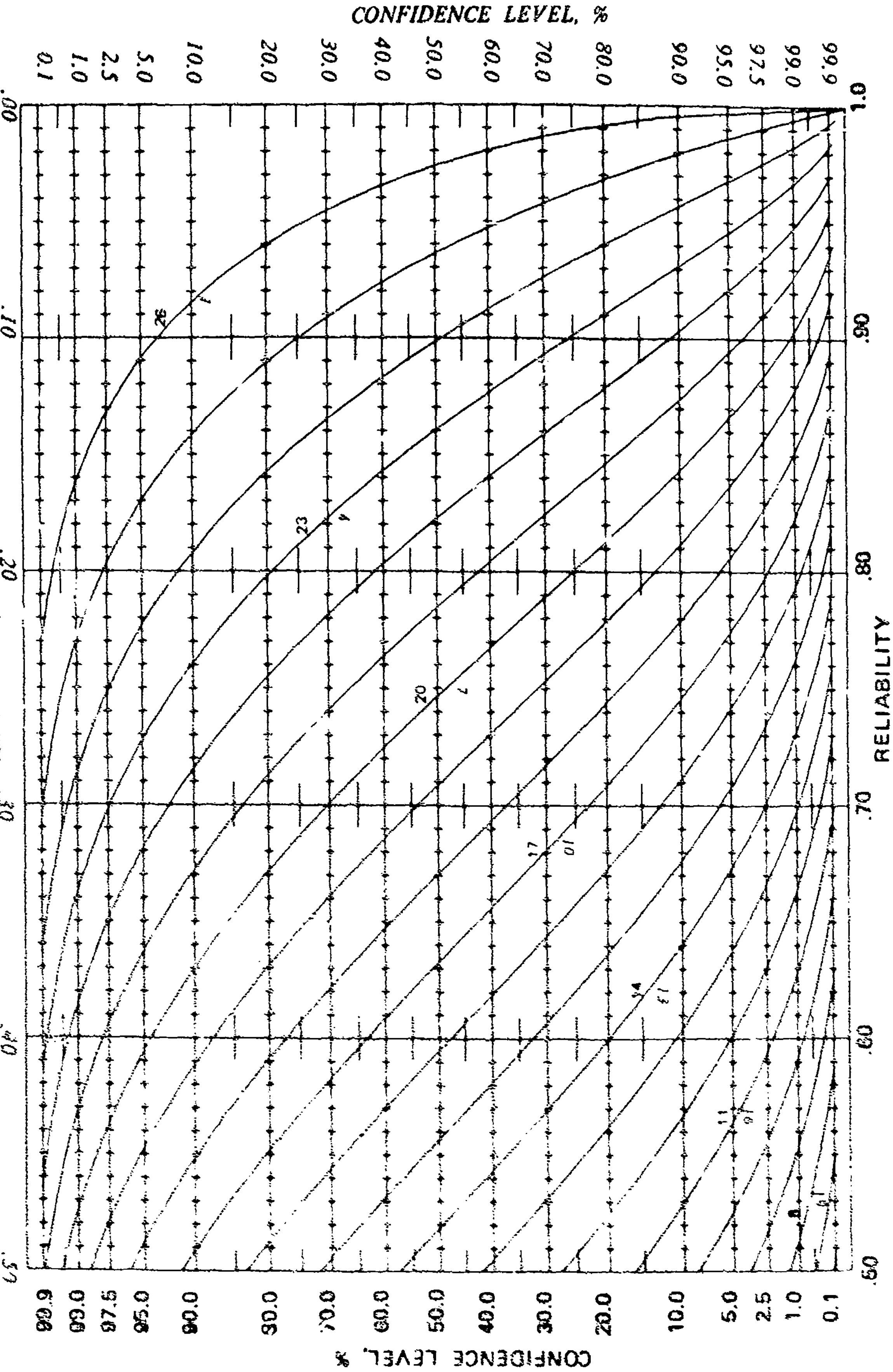

FIGURE 26. Confidence Level and Reliability for N = 26.

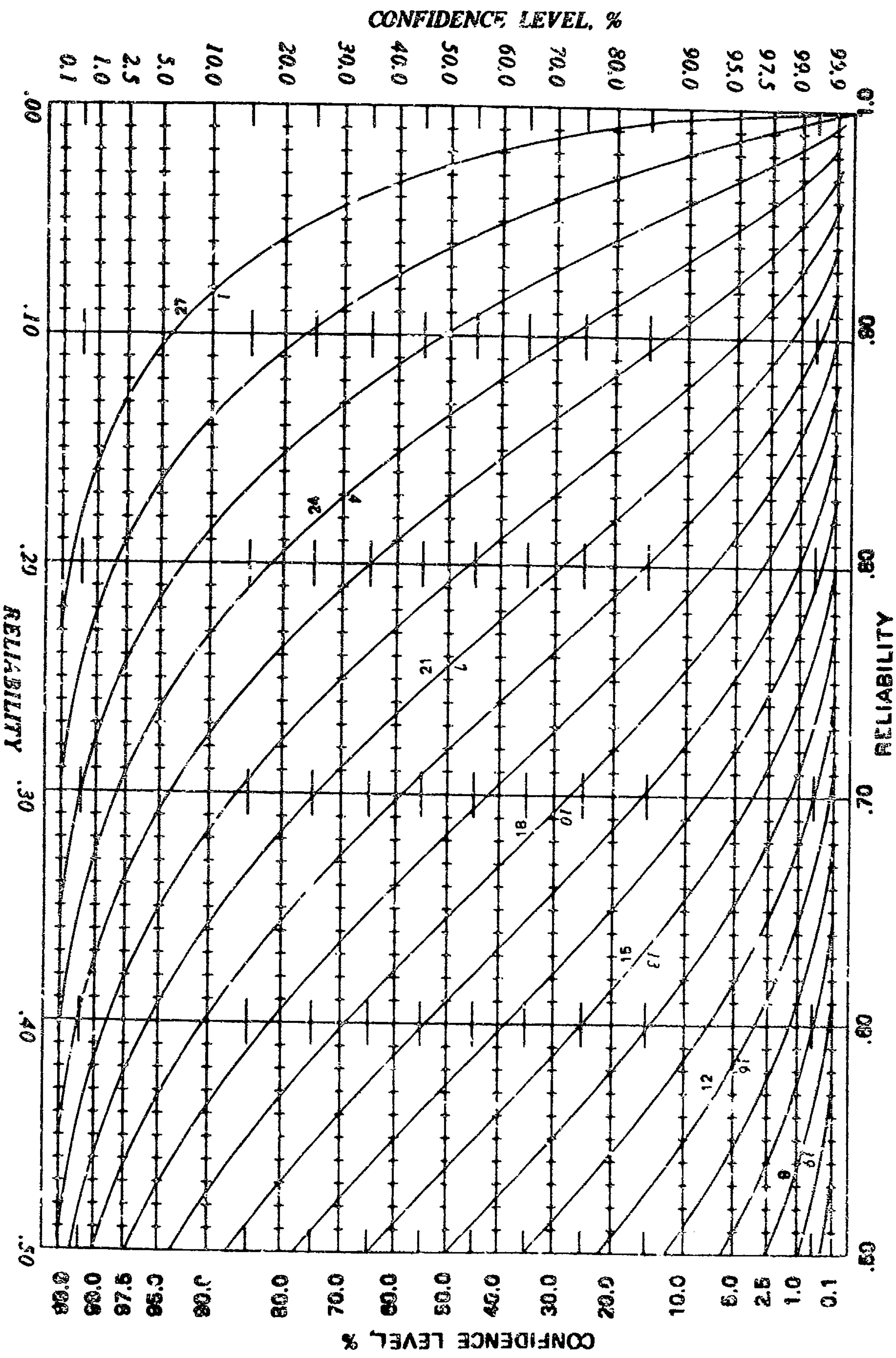

FIGURE 27. Confidence Level and Reliability for N = 27.

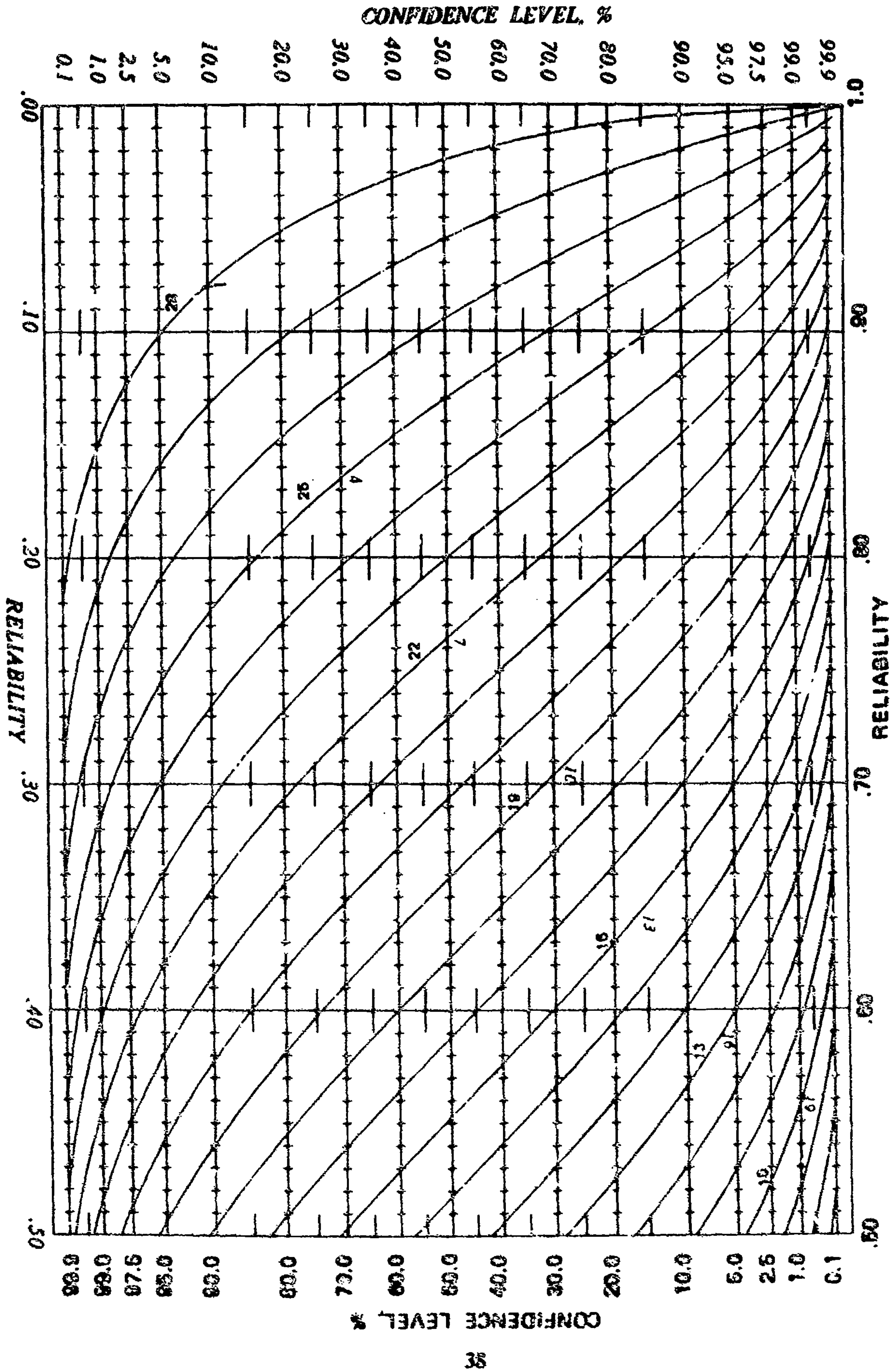

FIGURE 28. Confidence Level and Reliability for N = 28.

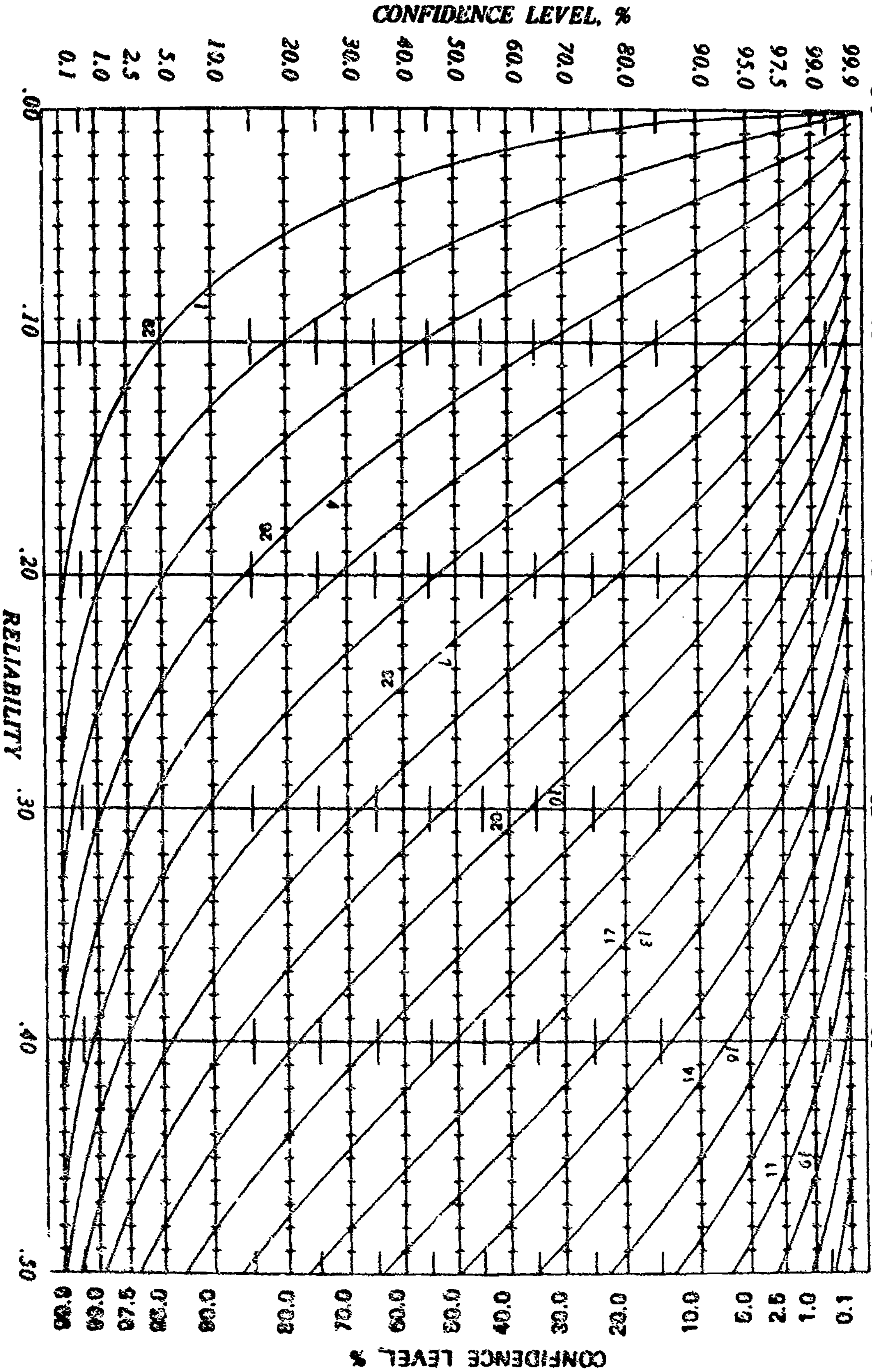

FIGURE 29. Confidence Level and Reliability for N = 29.

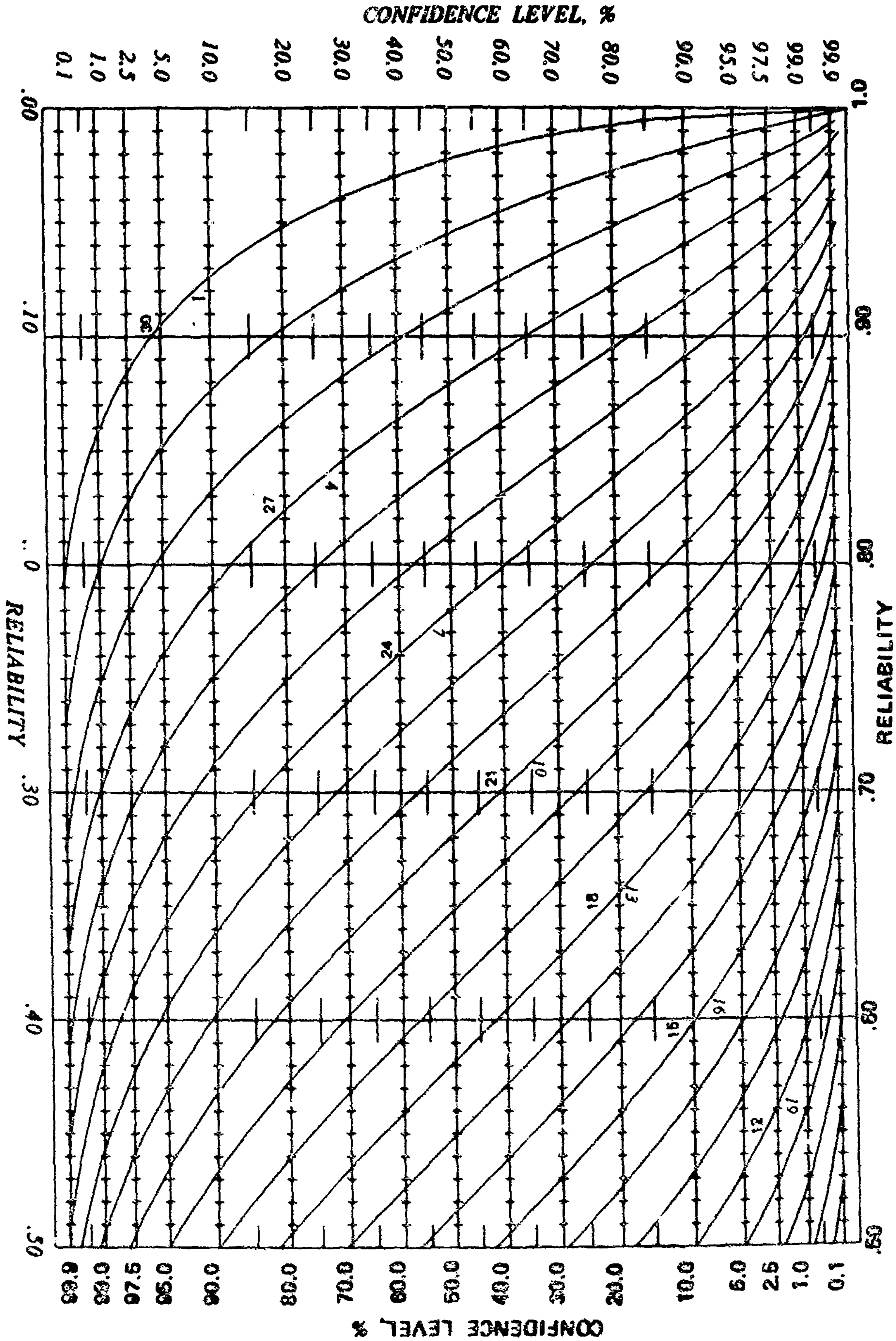

FIGURE 30. Confidence Level and Reliability for N = 30.

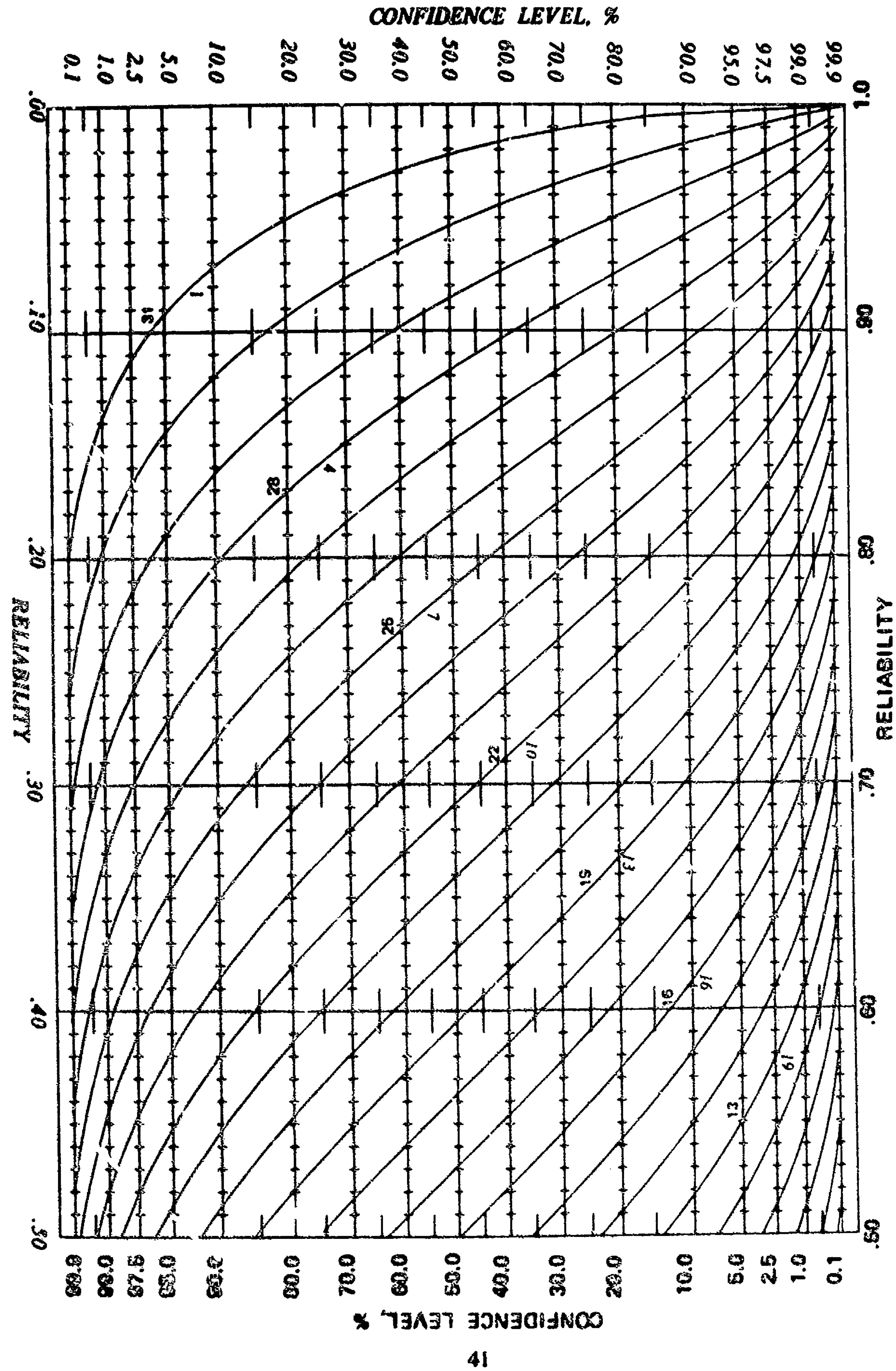

FIGURE 31. Confidence Level and Reliability for N = 31.

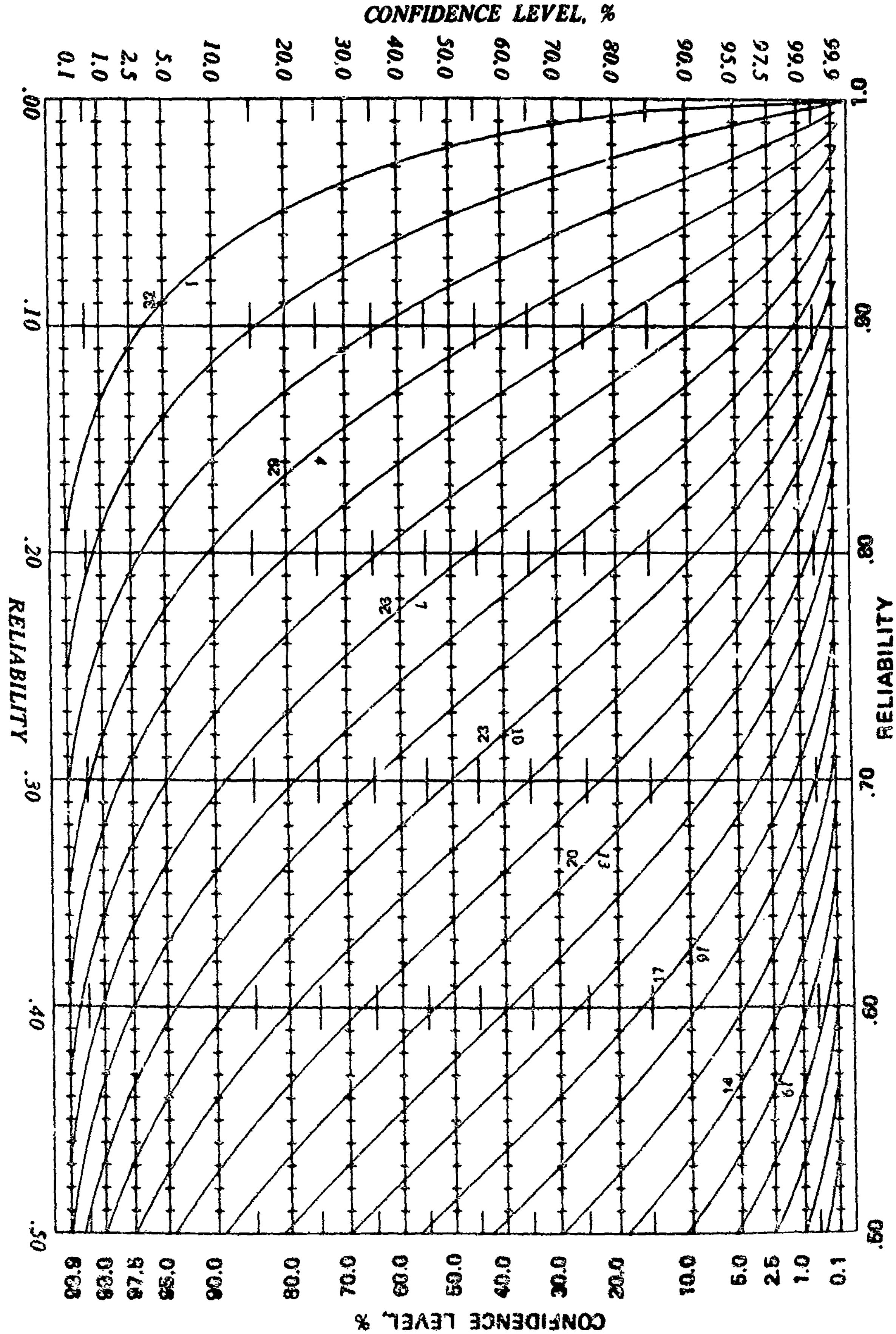

FIGURE 32. Confidence Level and Reliability for N = 32.

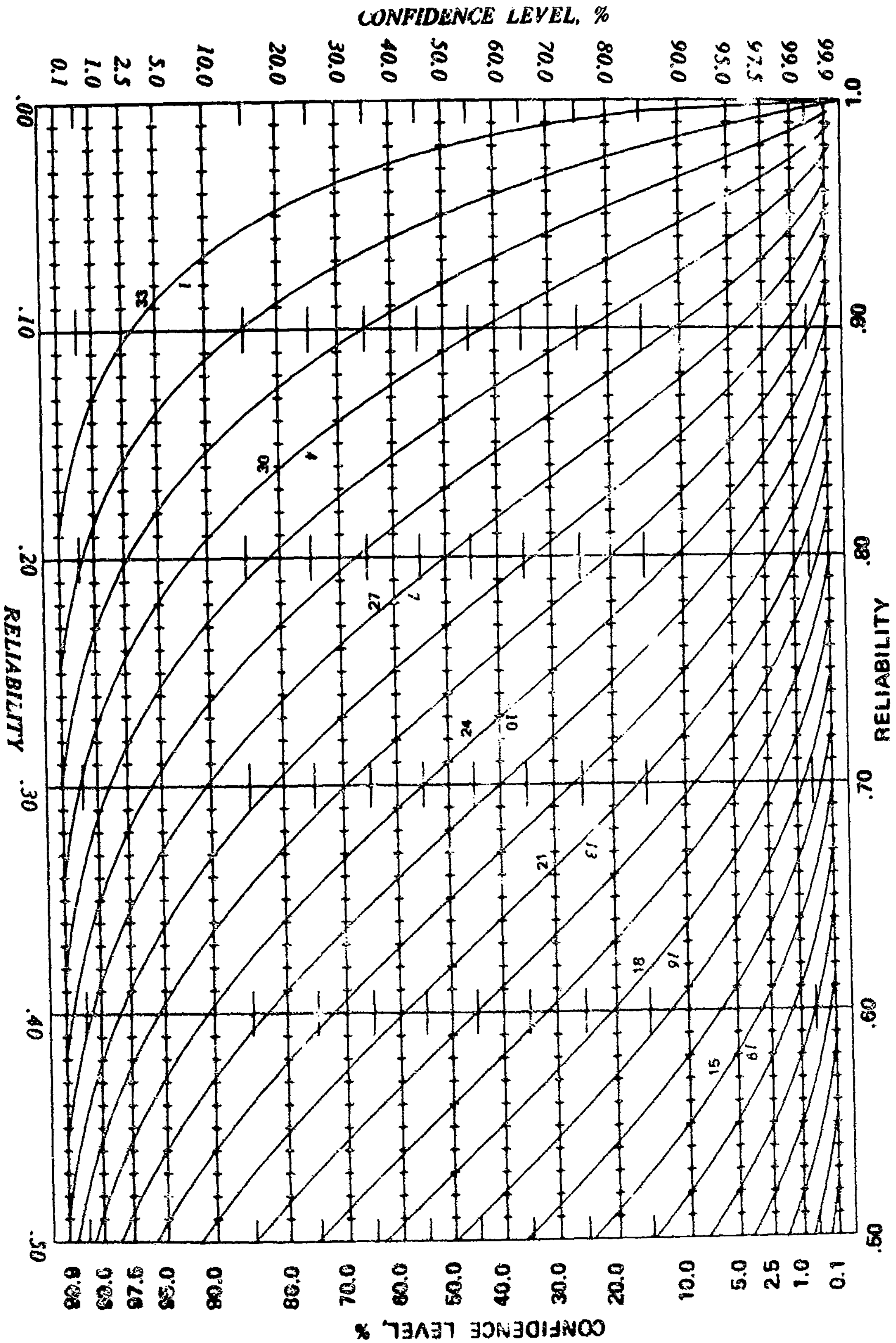

FIGURE 33. Confidence Level and Reliability for N = 33.

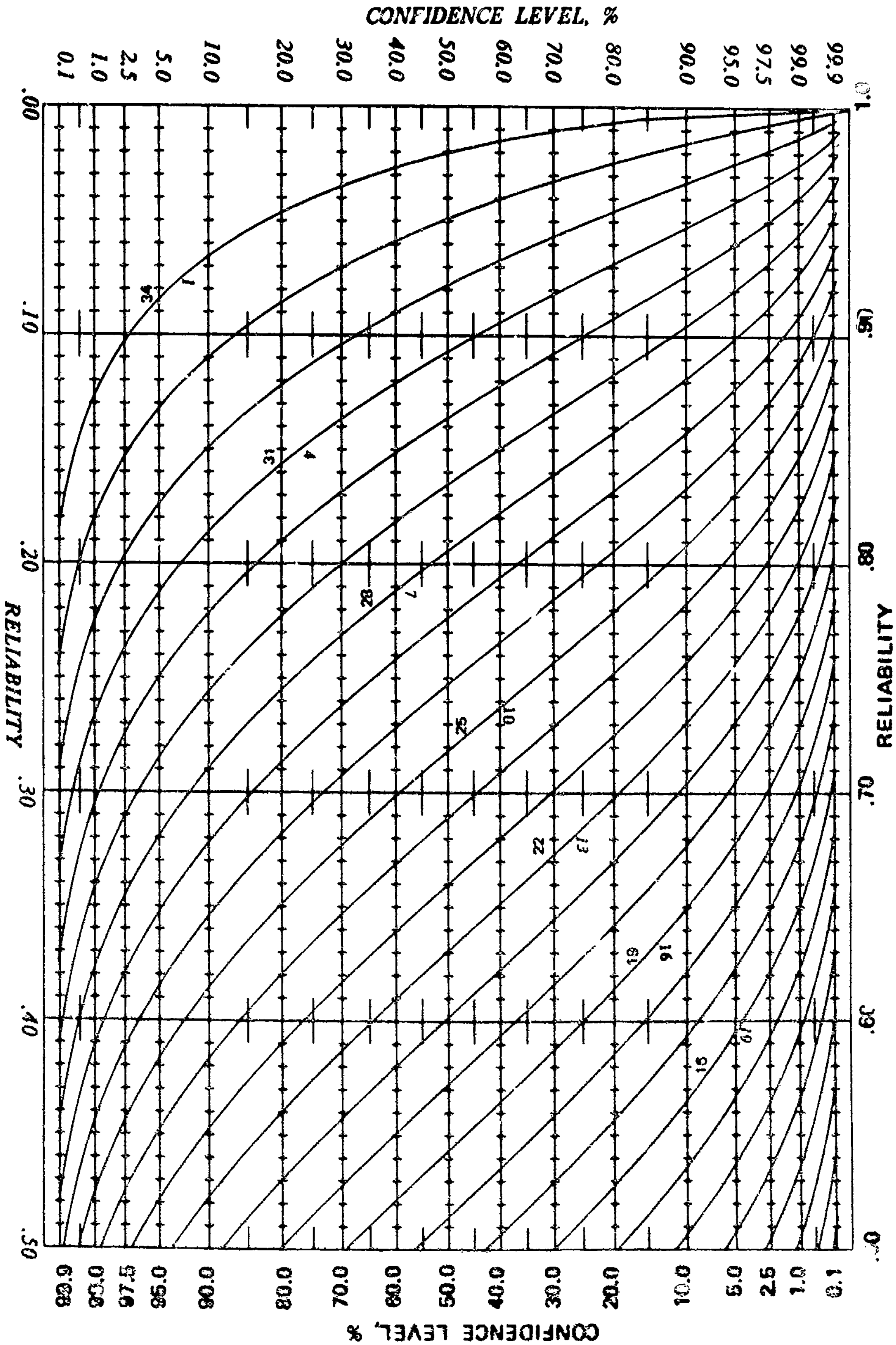

FIGURE 34. Confidence Level and Reliability for N = 34.

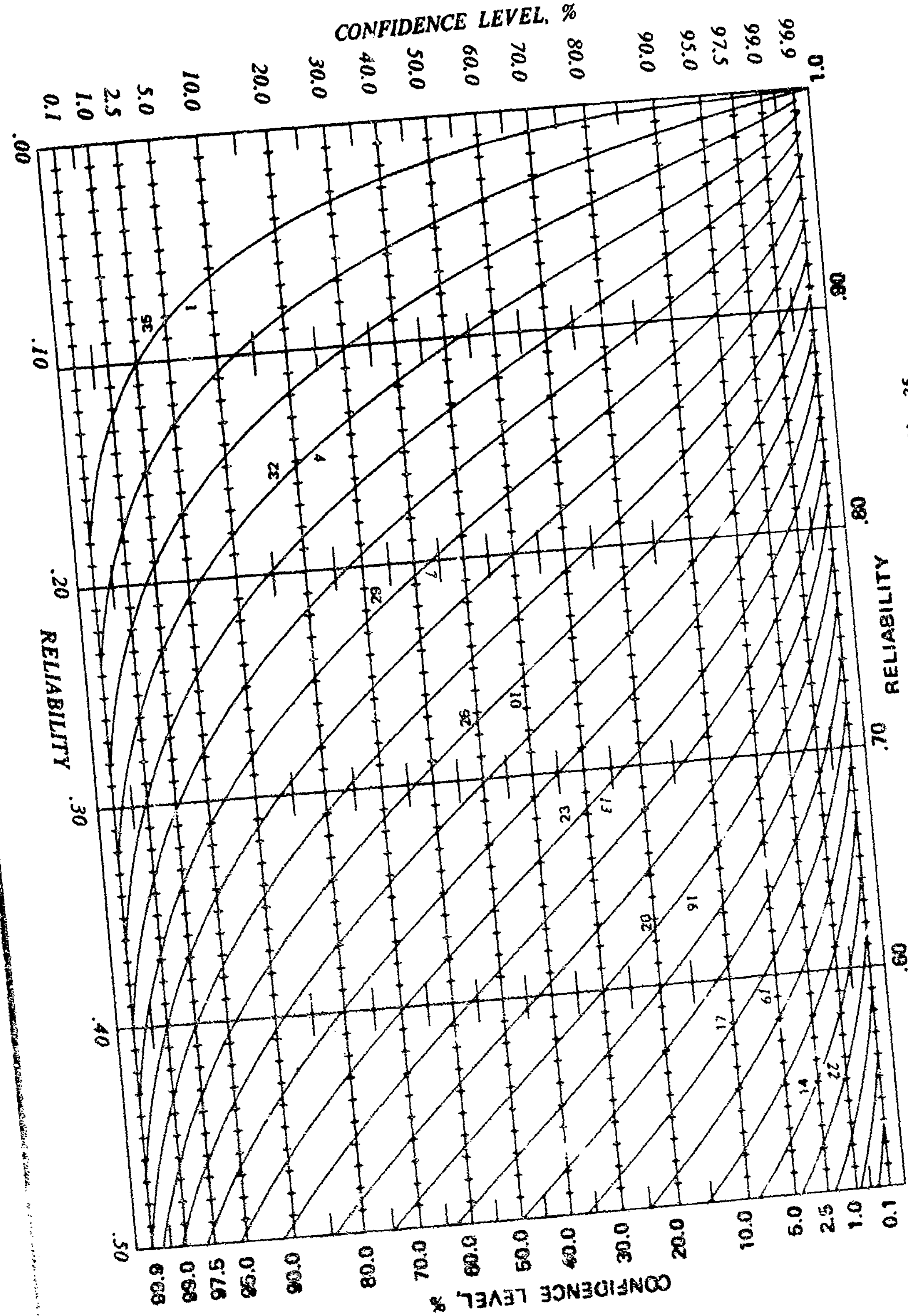

FIGURE 35. Confidence Level and Reliability for N = 35.

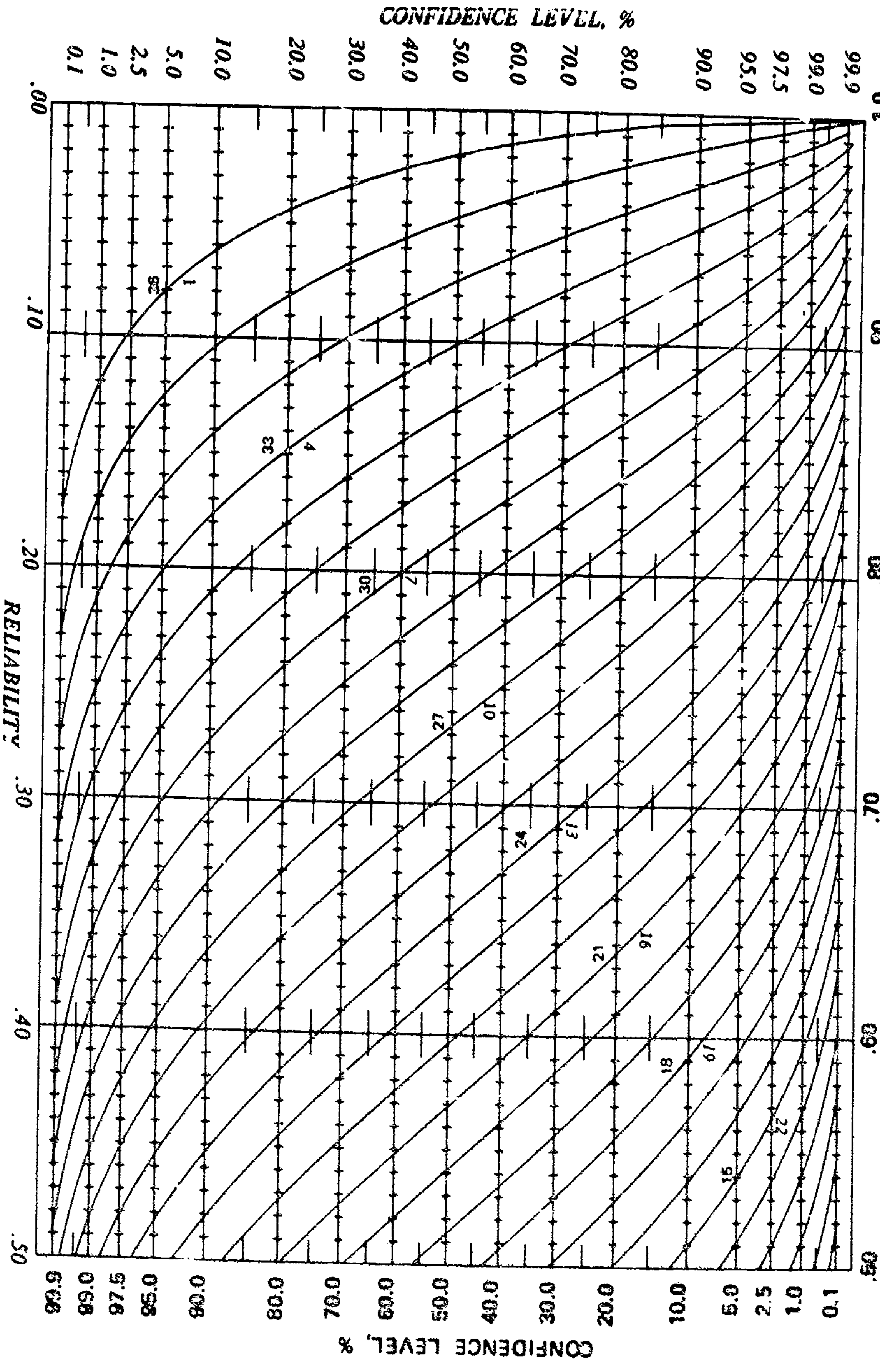

FIGURE 36. Confidence Level and Reliability for N = 36.

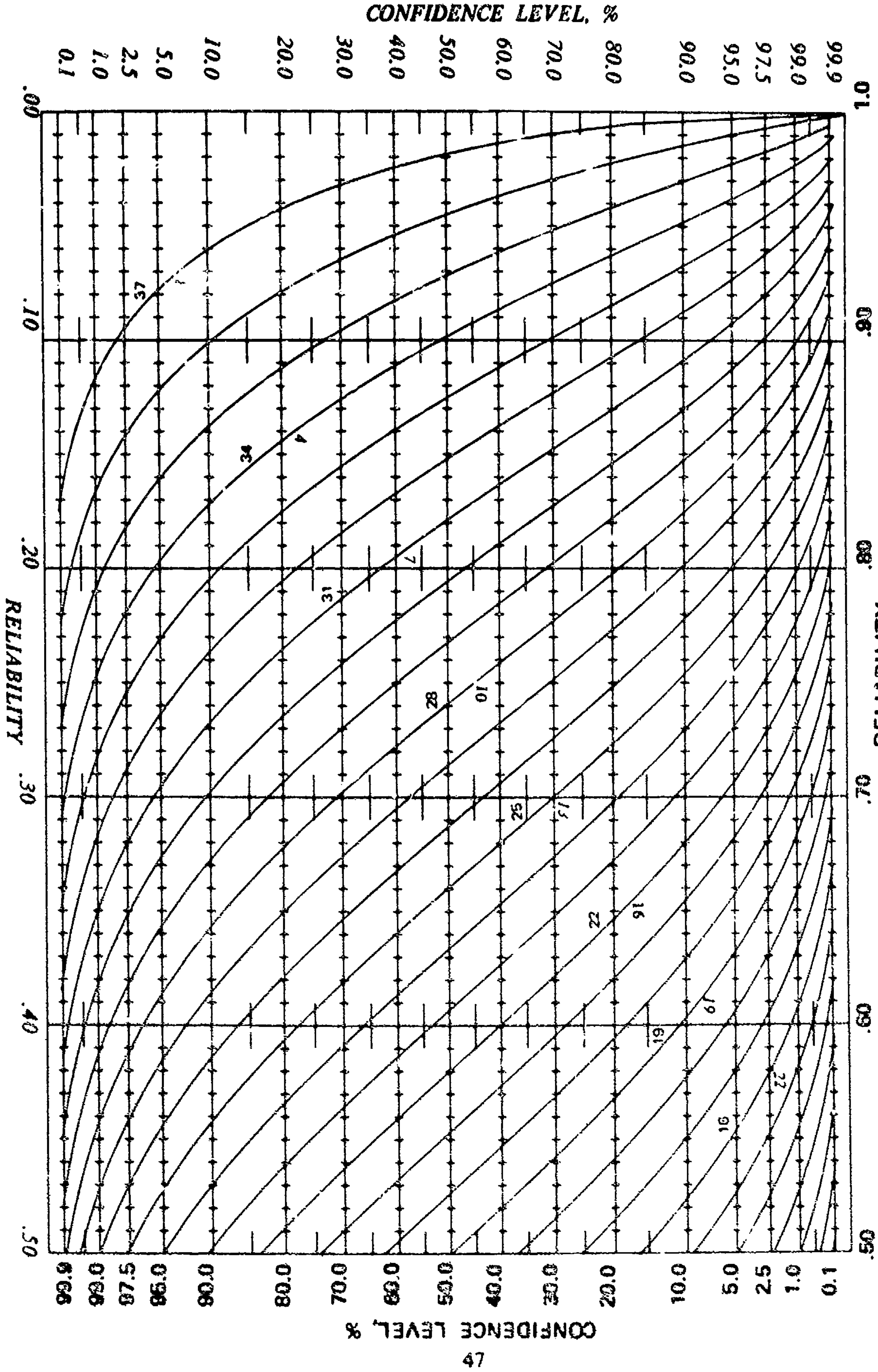

FIGURE 37. Confidence Level and Reliability for N = 37.

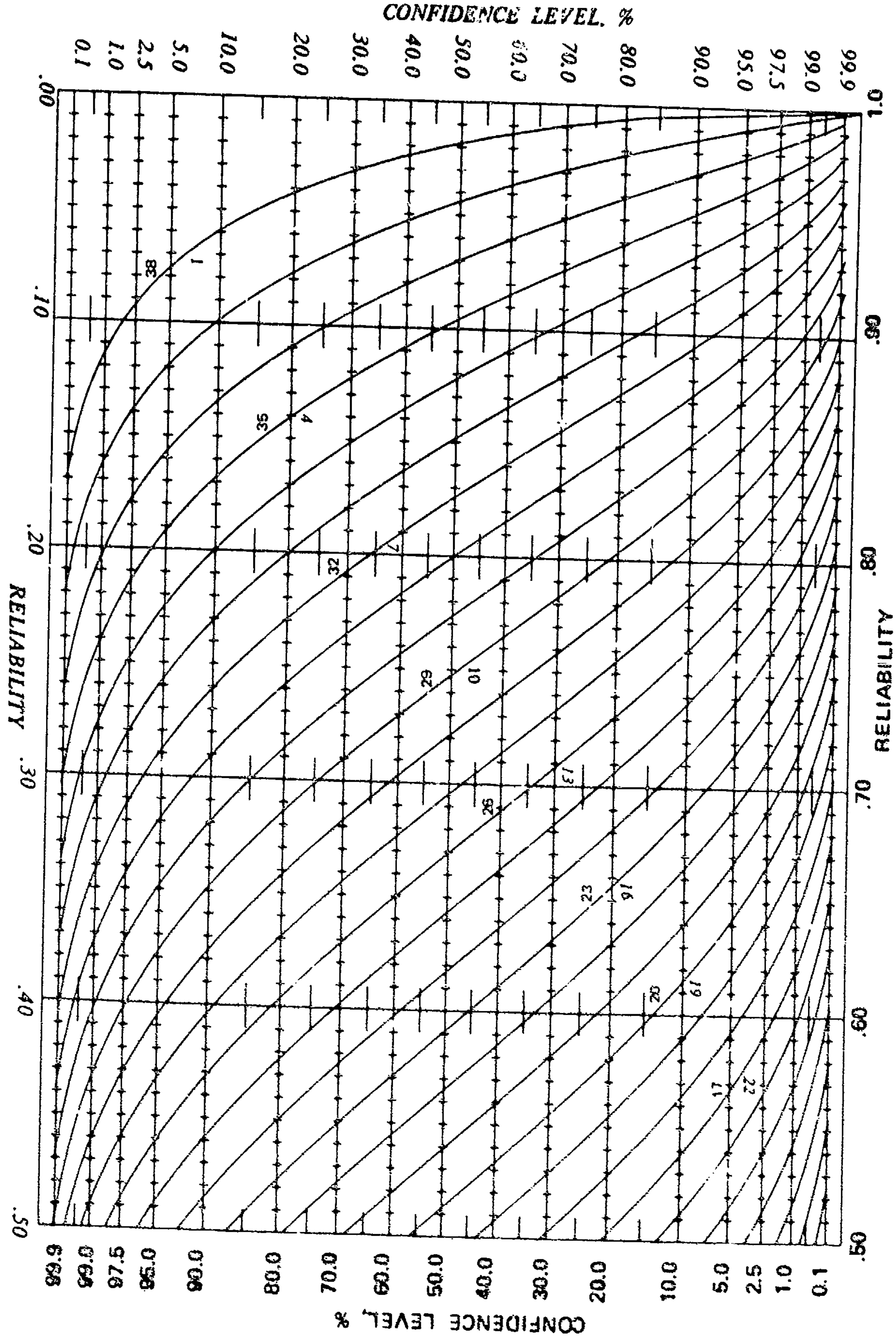

FIGURE 38. Confidence Level and Reliability for N = 38.

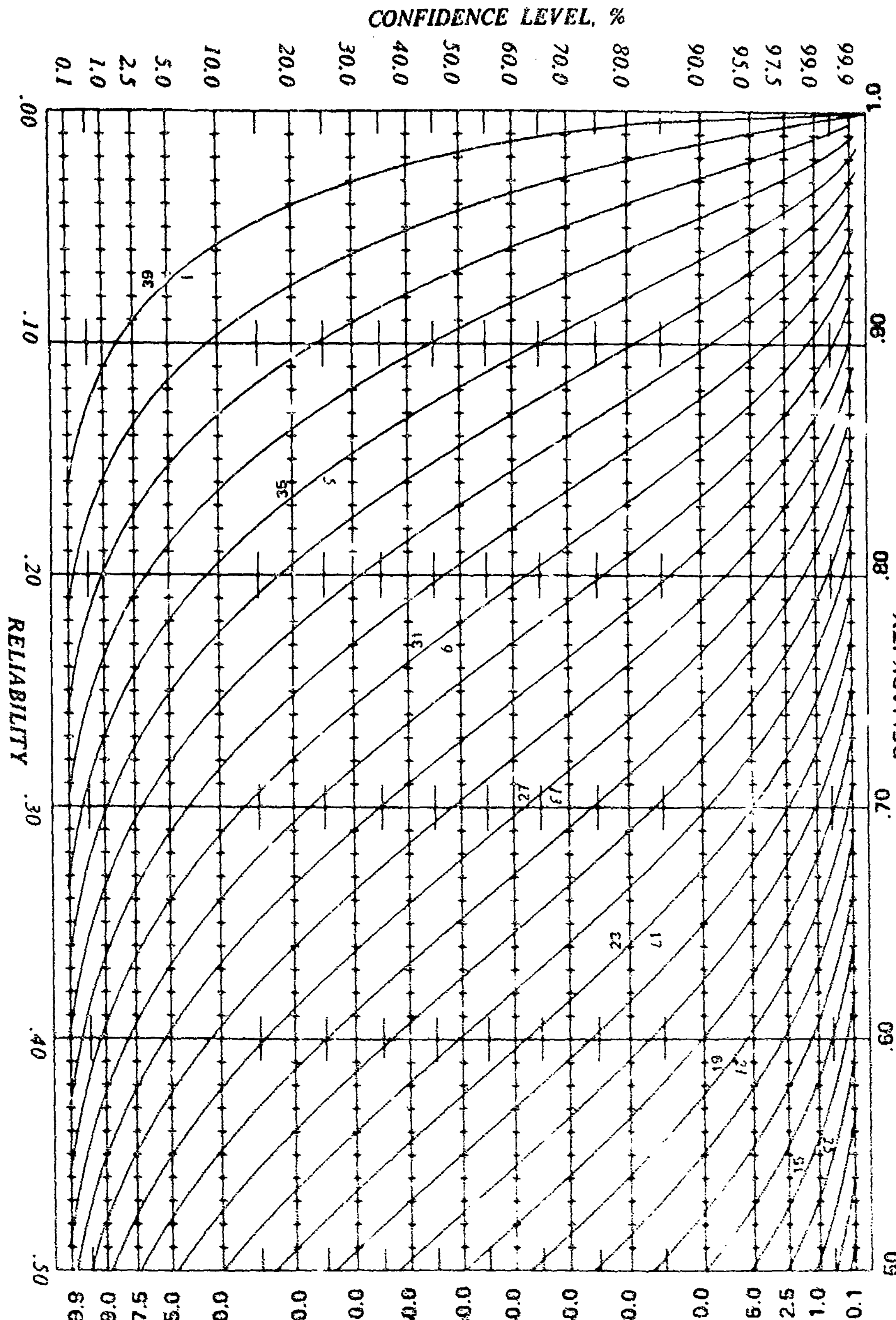

FIGURE 39. Confidence Level and Reliability for N = 39.

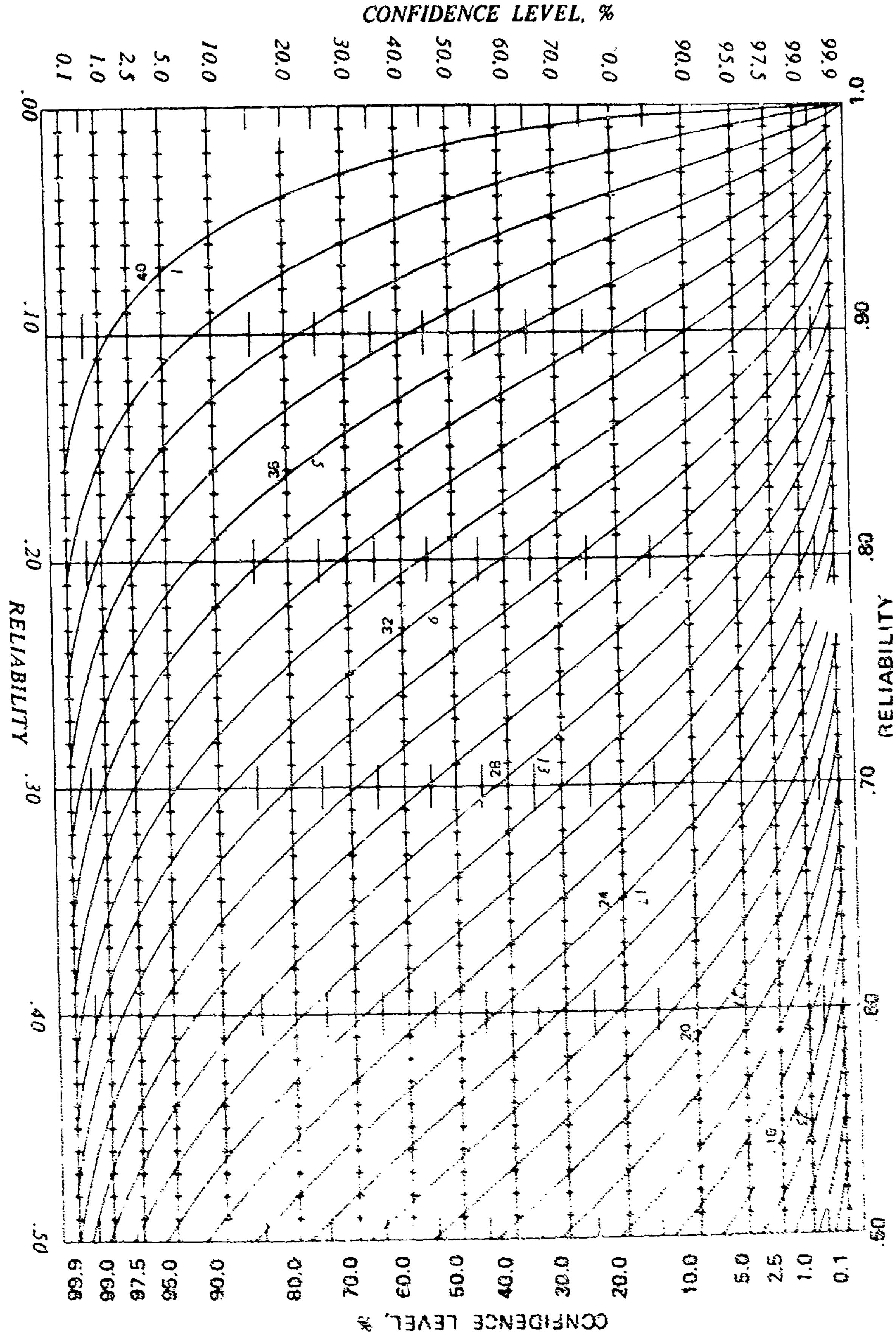

FIGURE 40. Confidence Level and Reliability for N = 40.

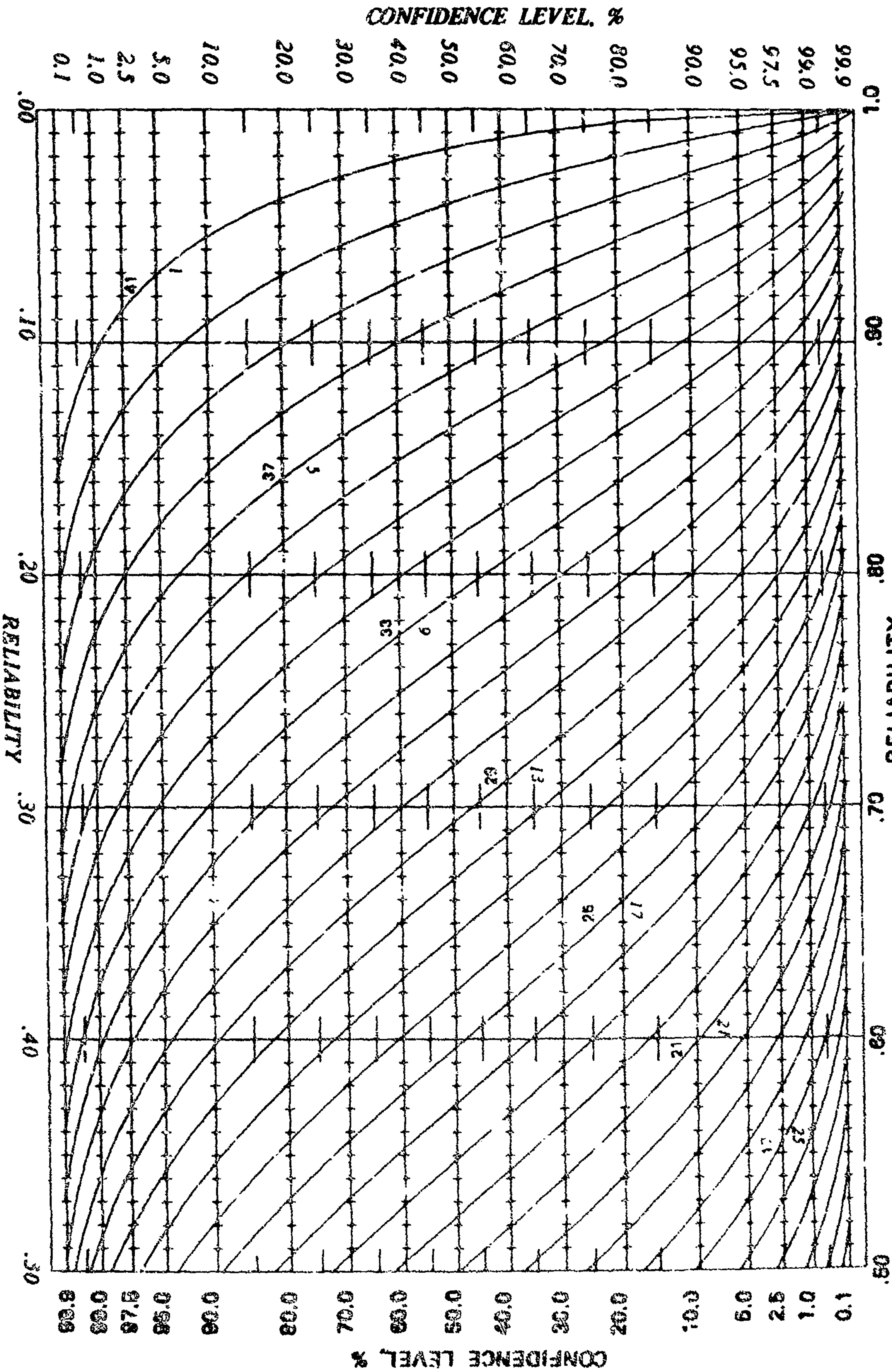

FIGURE 41. Confidence Level and Reliability for N = 41.

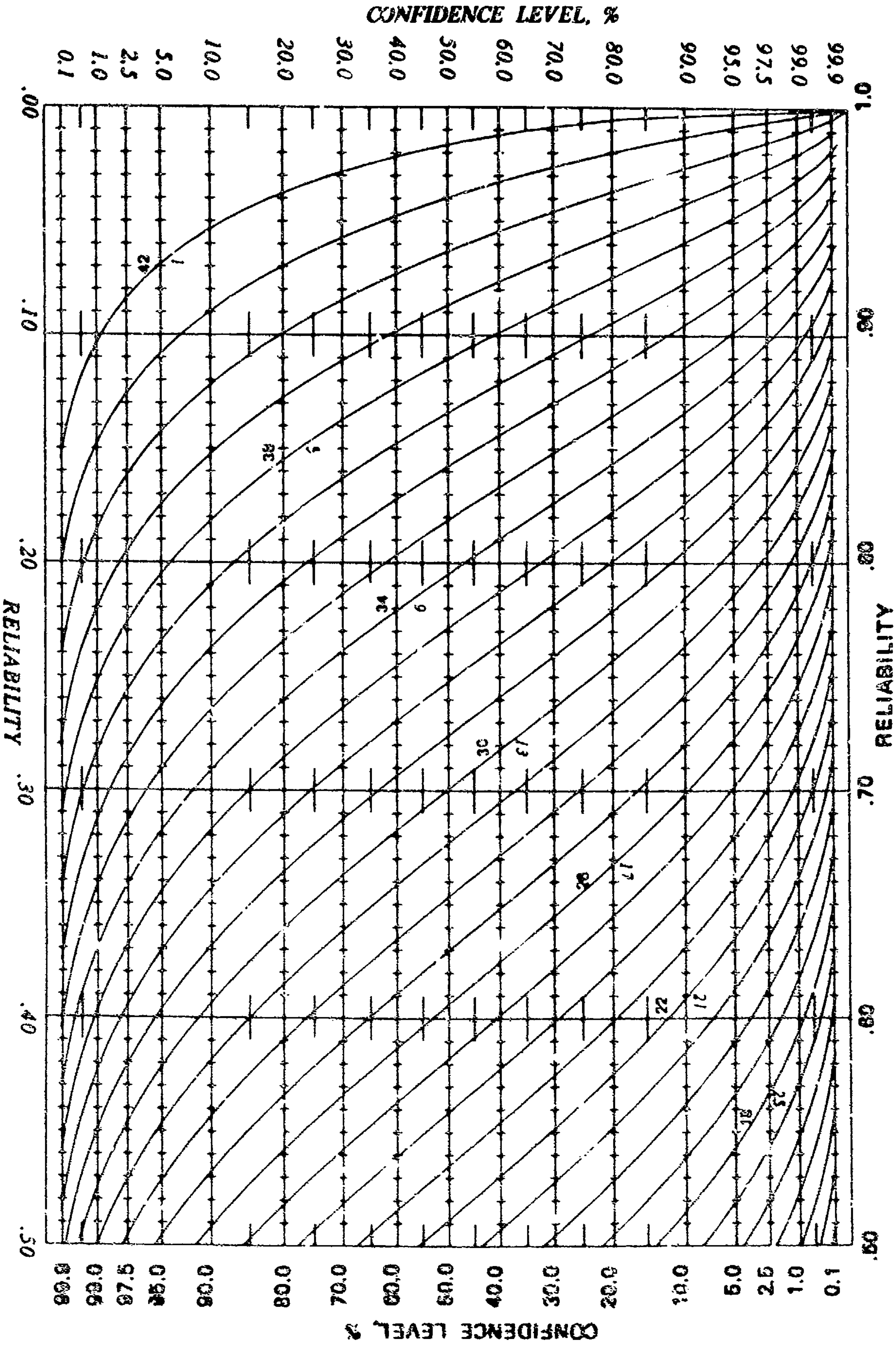

FIGURE 42. Confidence Level and Reliability for N = 42.

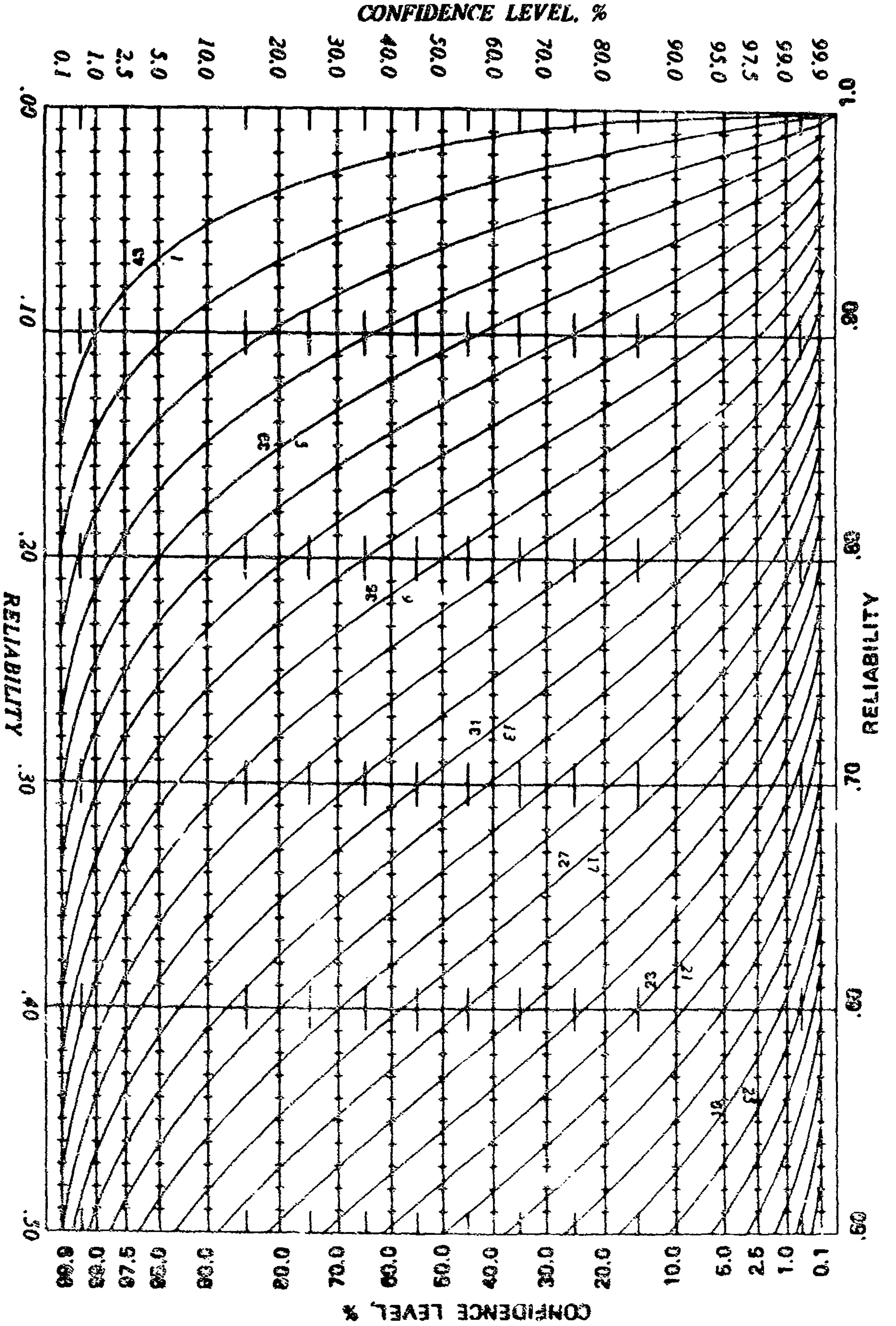

FIGURE 43. Confidence Level and Reliability for N = 43.

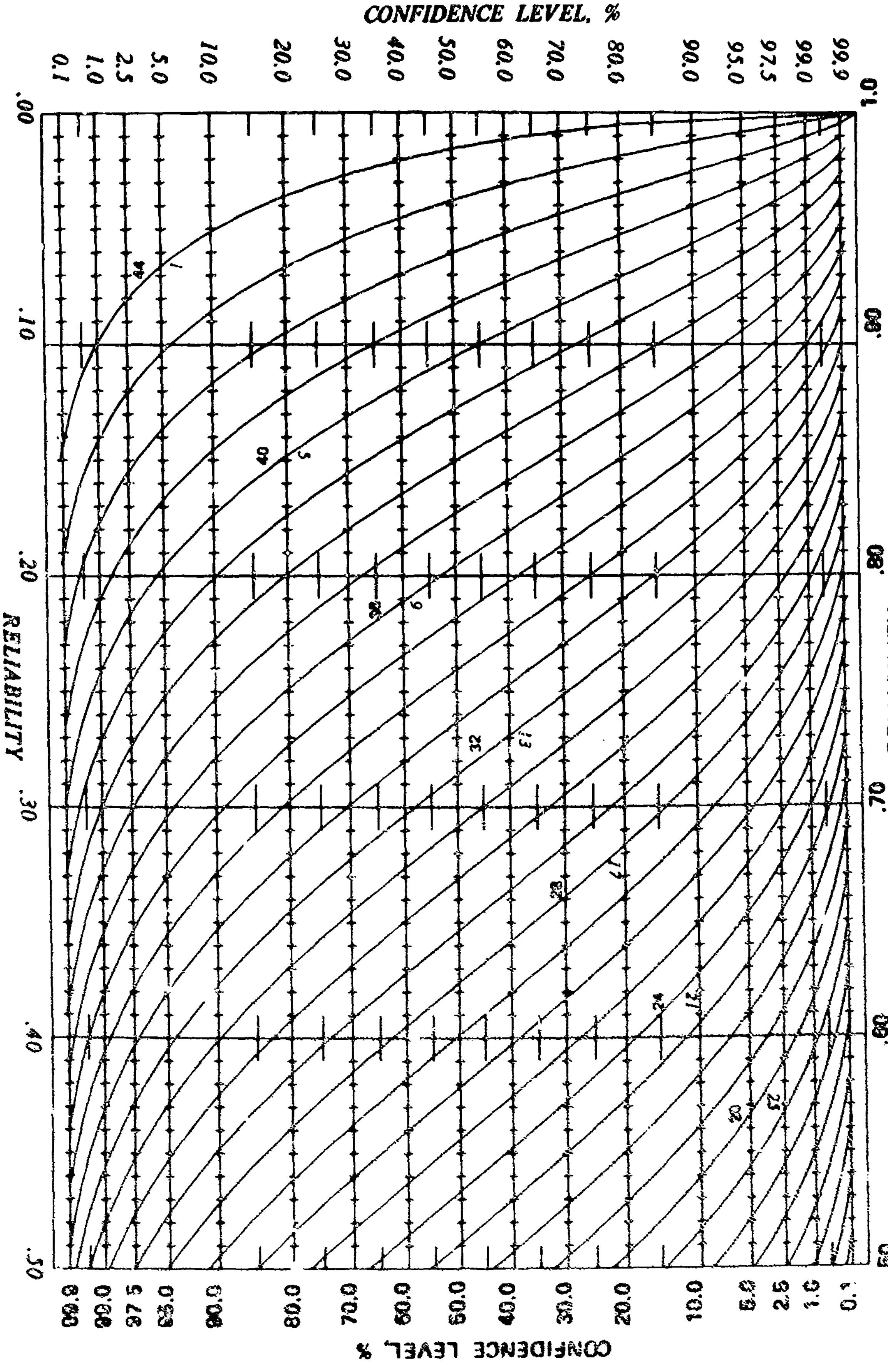

FIGURE 44. Confidence Level and Reliability for N = 44.

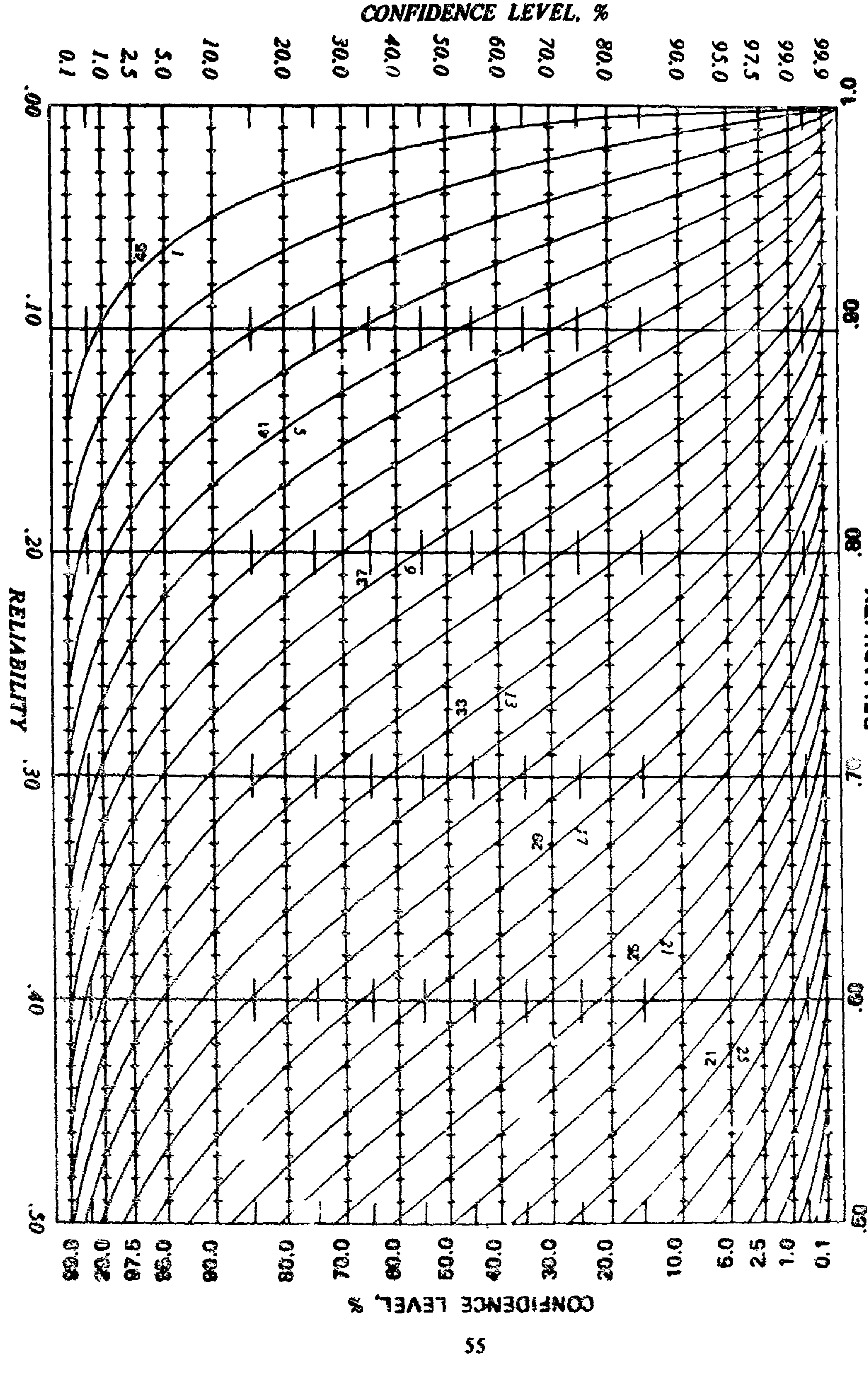

FIGURE 45. Confidence Level and Reliability for N = 45.

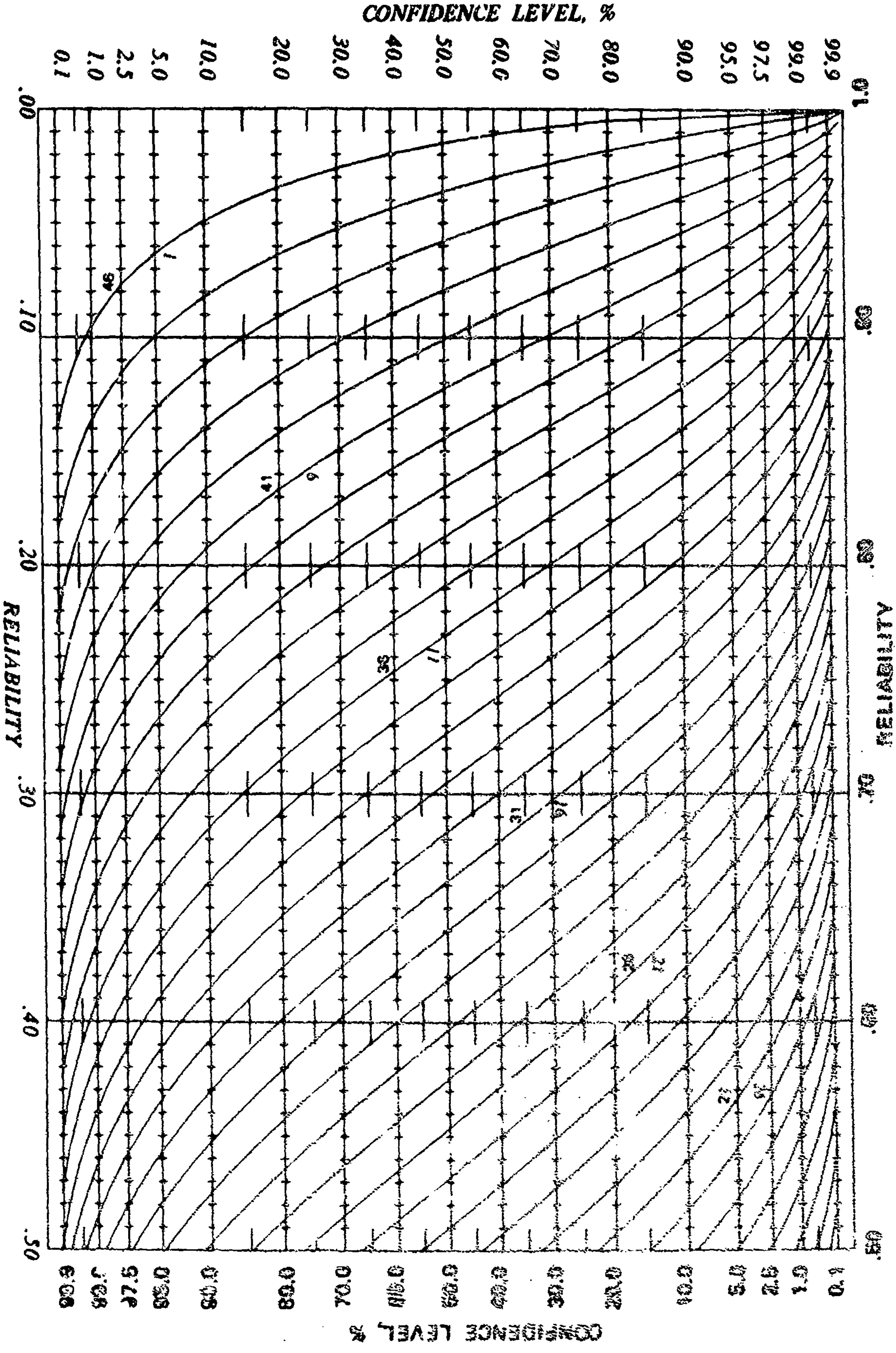

FIGURE 46. Confidence Level and Reliability for N = 46.

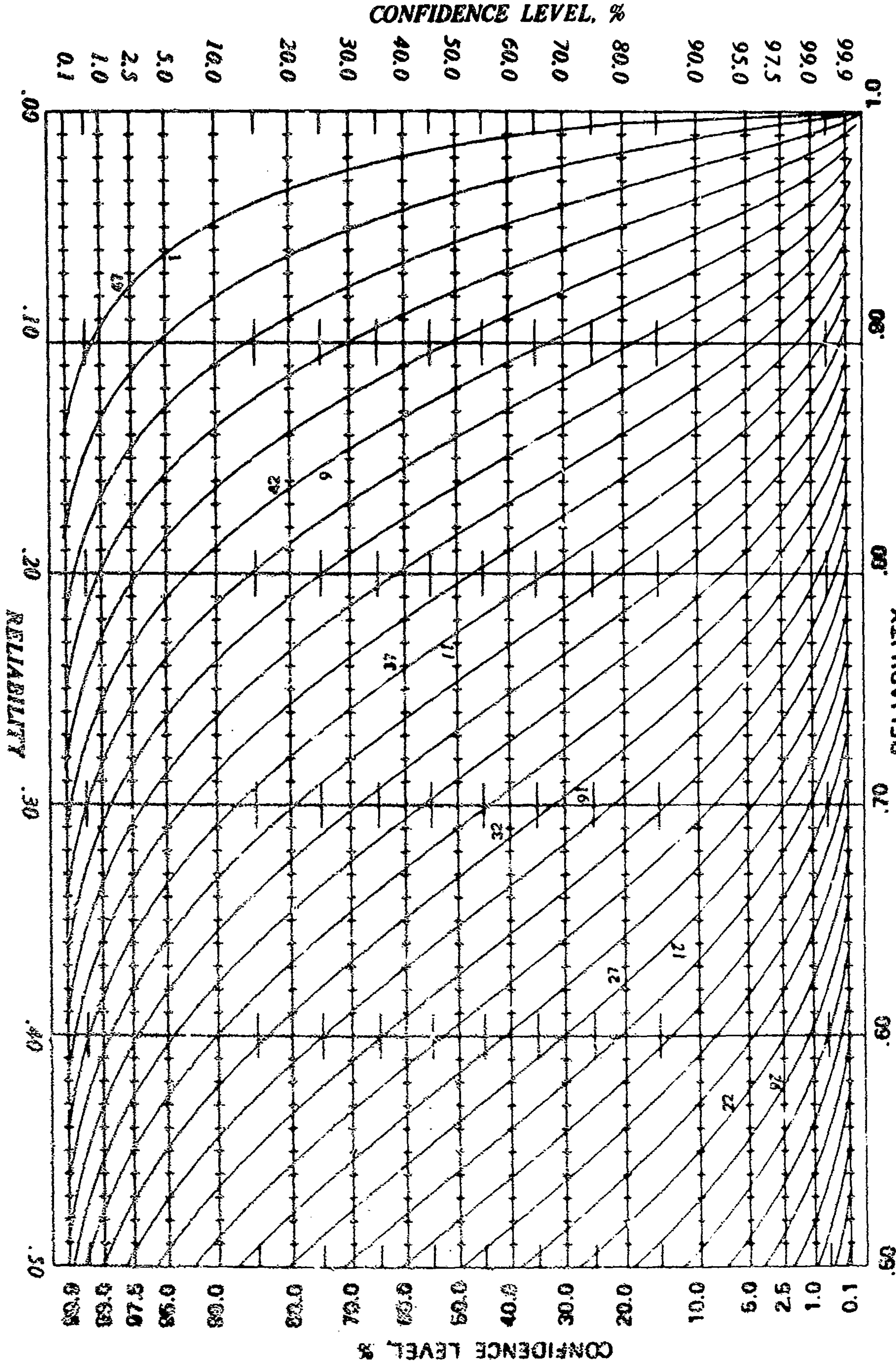

FIGURE 47. Confidence Level and Reliability for N = 47.

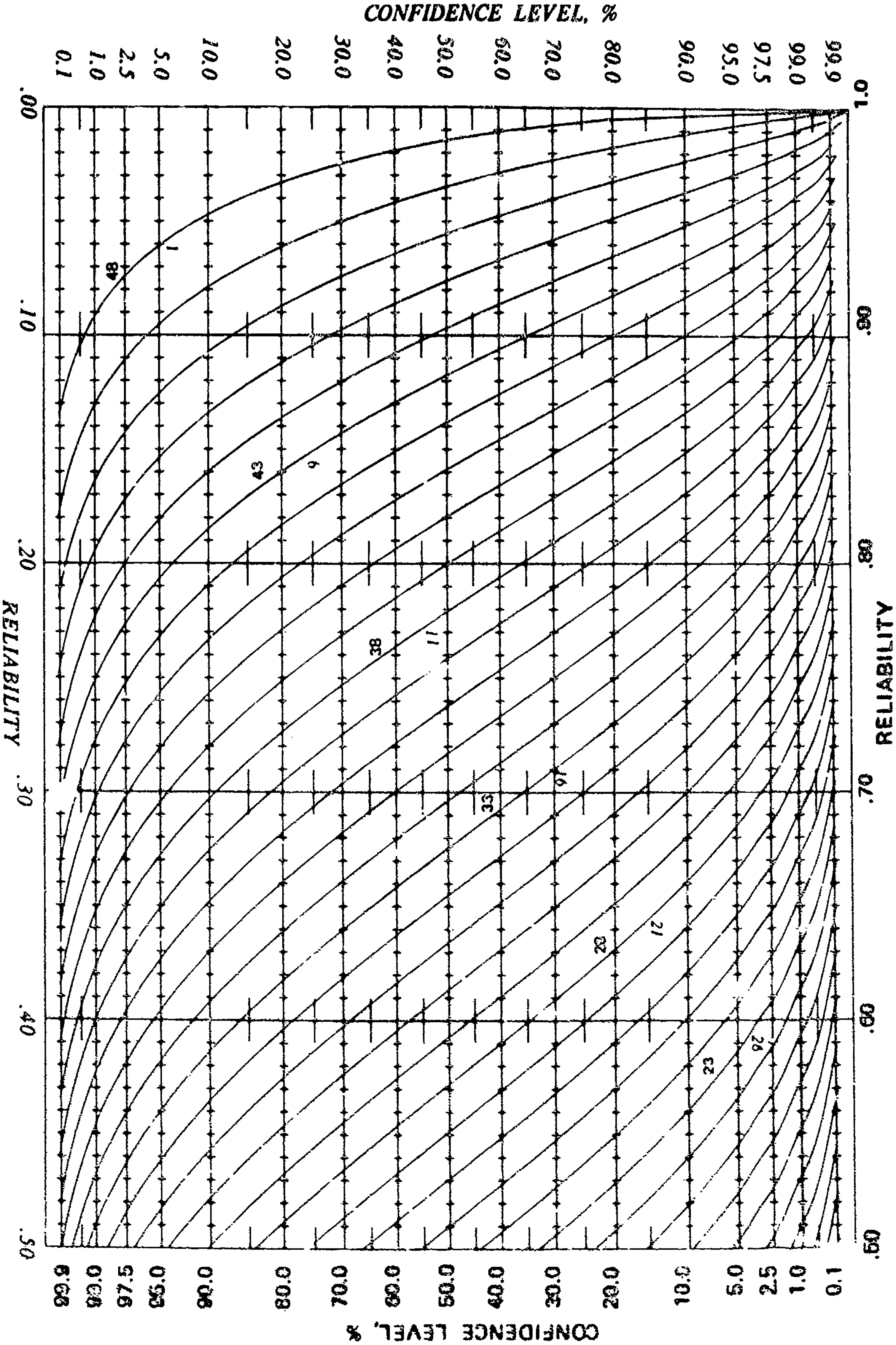

FIGURE 48. Confidence Level and Reliability for N = 48.

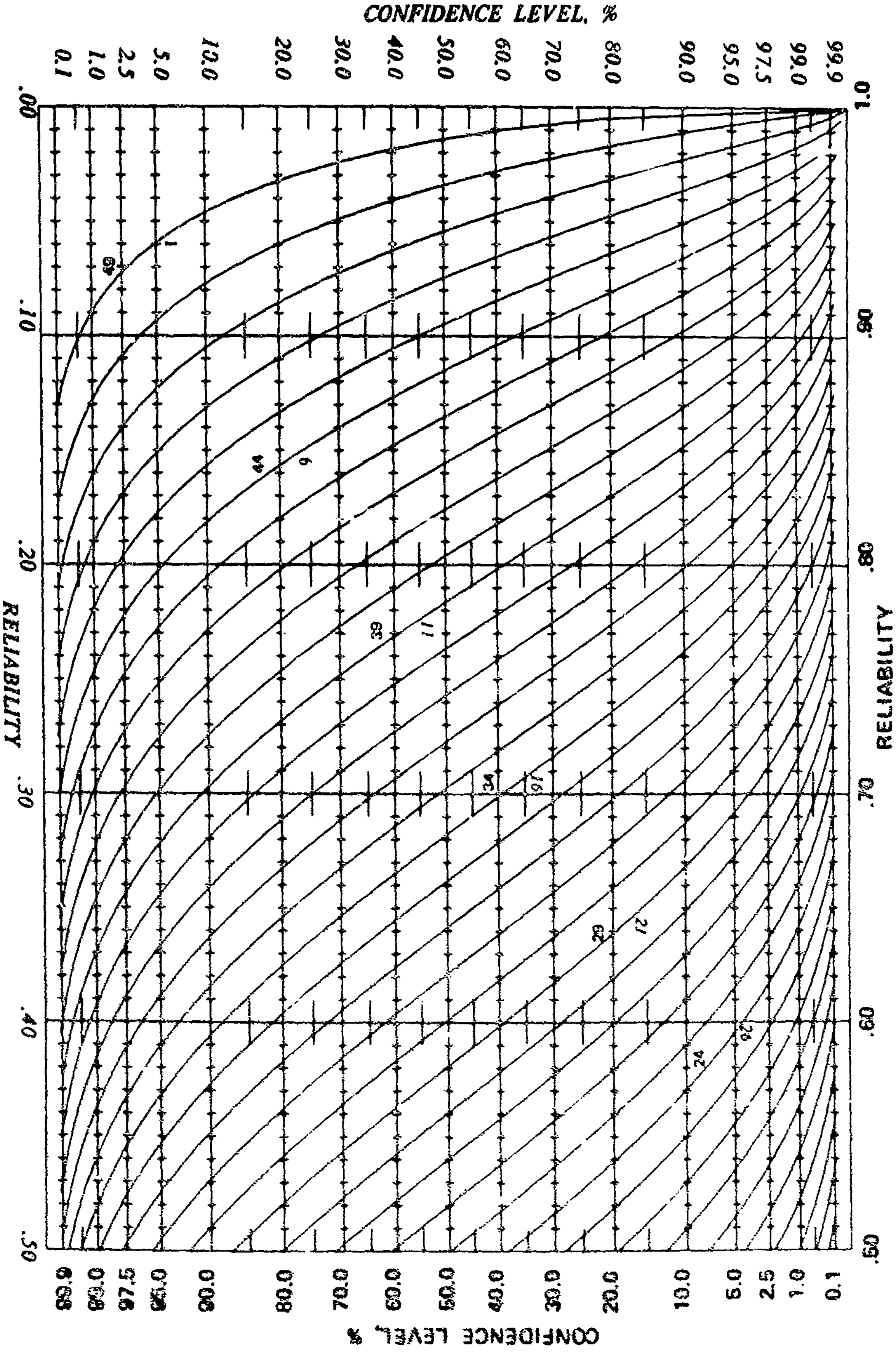

FIGURE 49. Confidence Level and Reliability for N = 49.

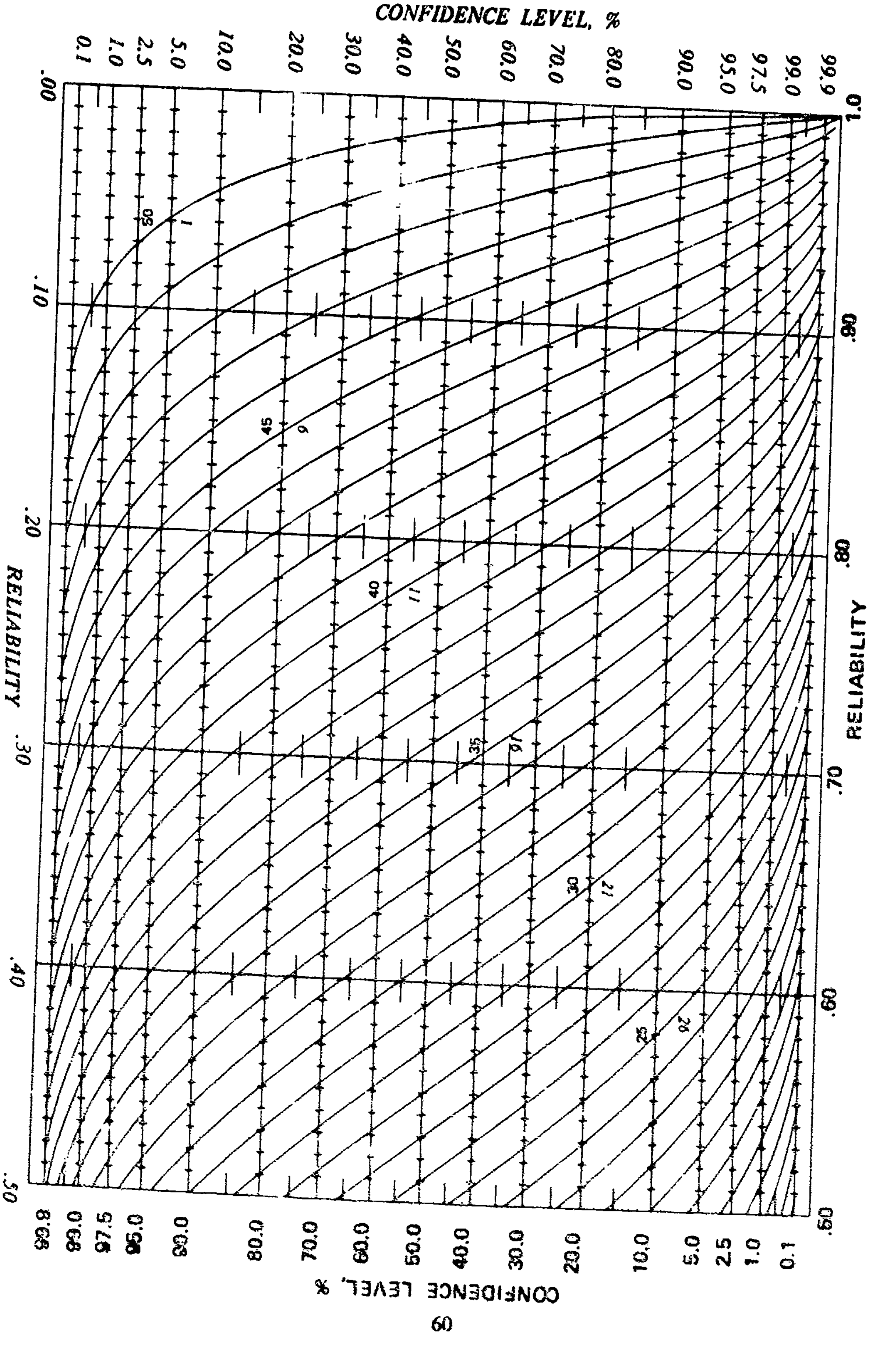

FIGURE 50. Confidence Level and Reliability for N = 50.

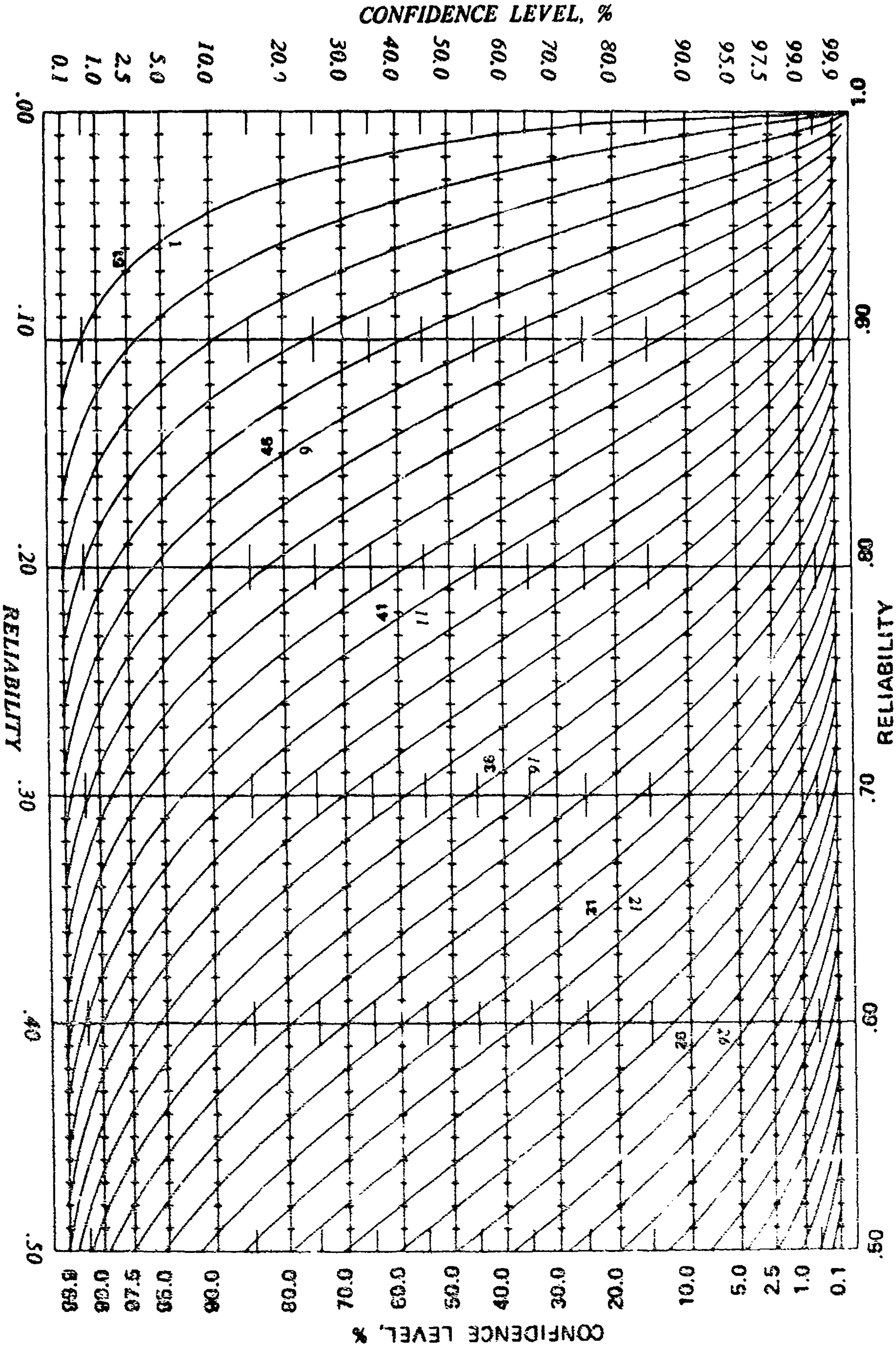

FIGURE 51. Confidence Level and Reliability for N = 51.

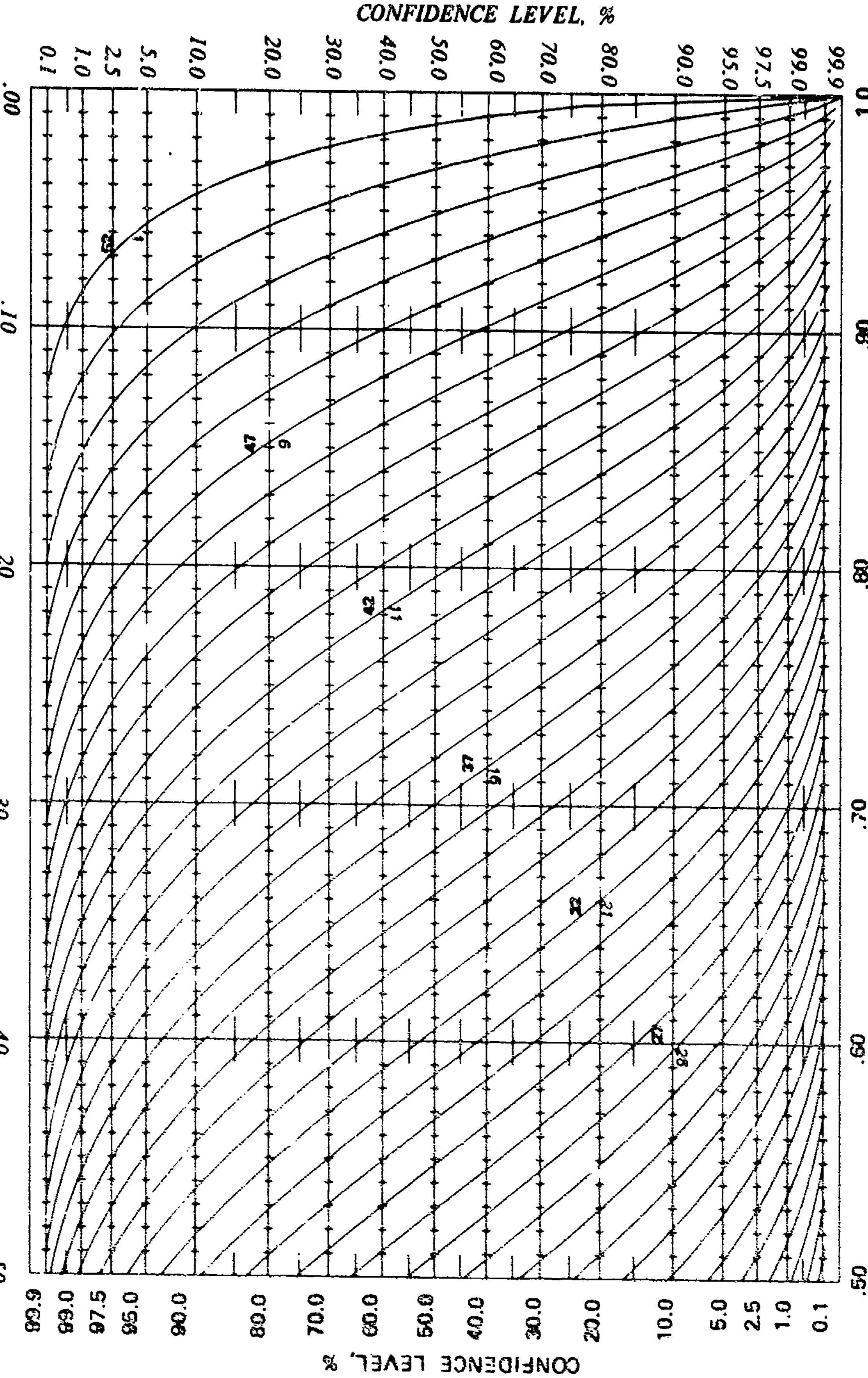

FIGURE 52. Confidence Level and Reliability for N = 52.

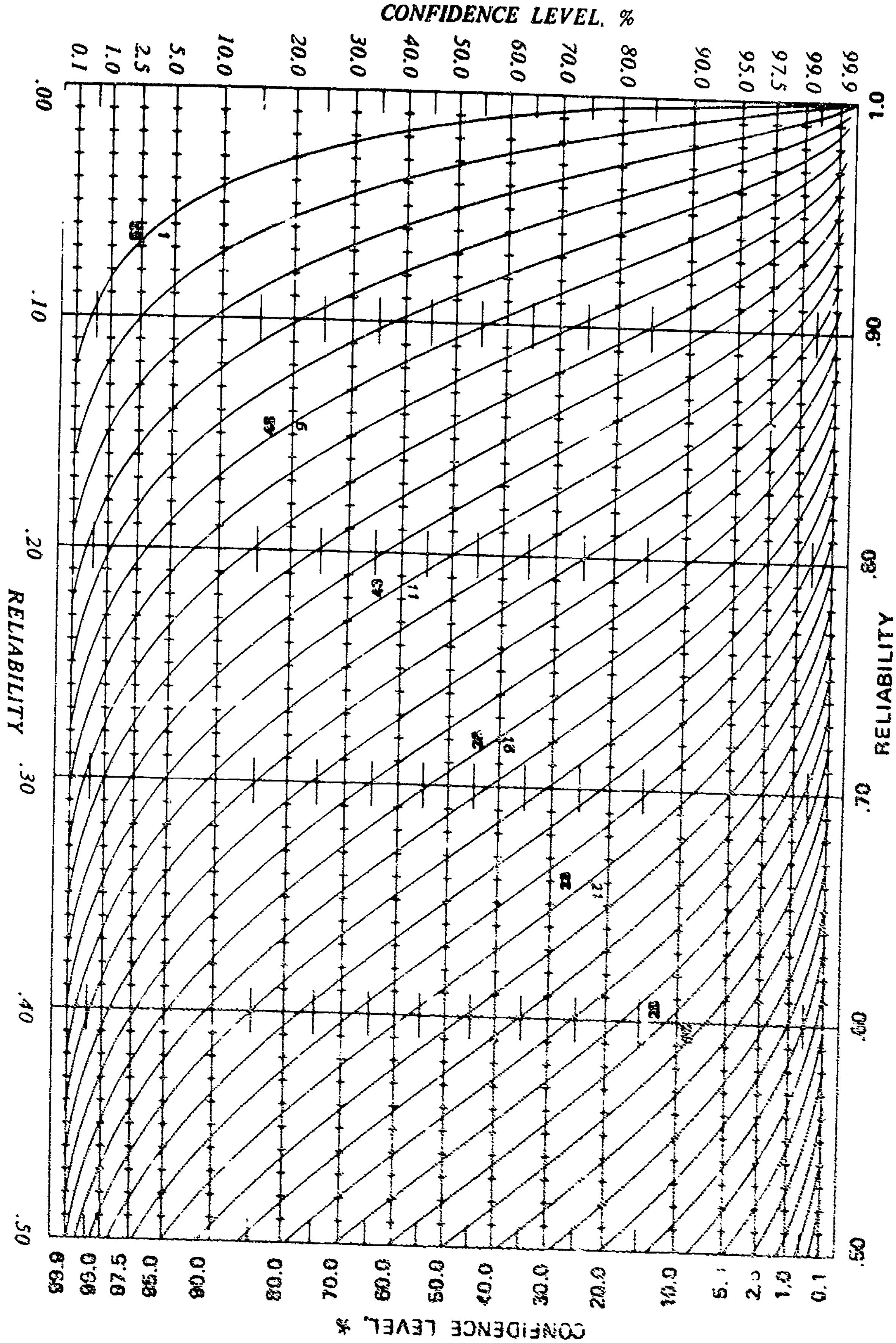

FIGURE 53. Confidence Level and Reliability for N = 53.

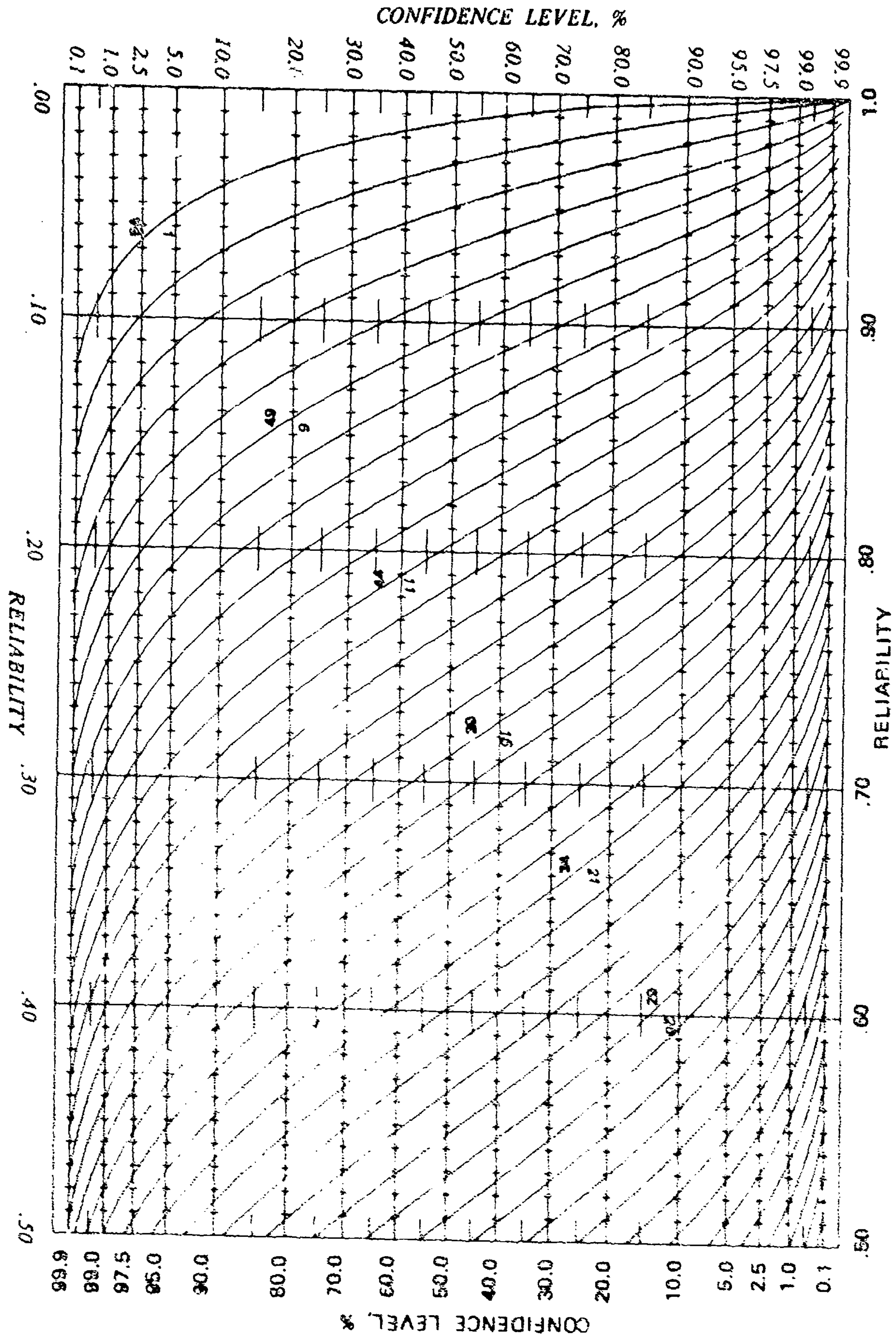

FIGURE 54. Confidence Level and Reliability for N = 54.

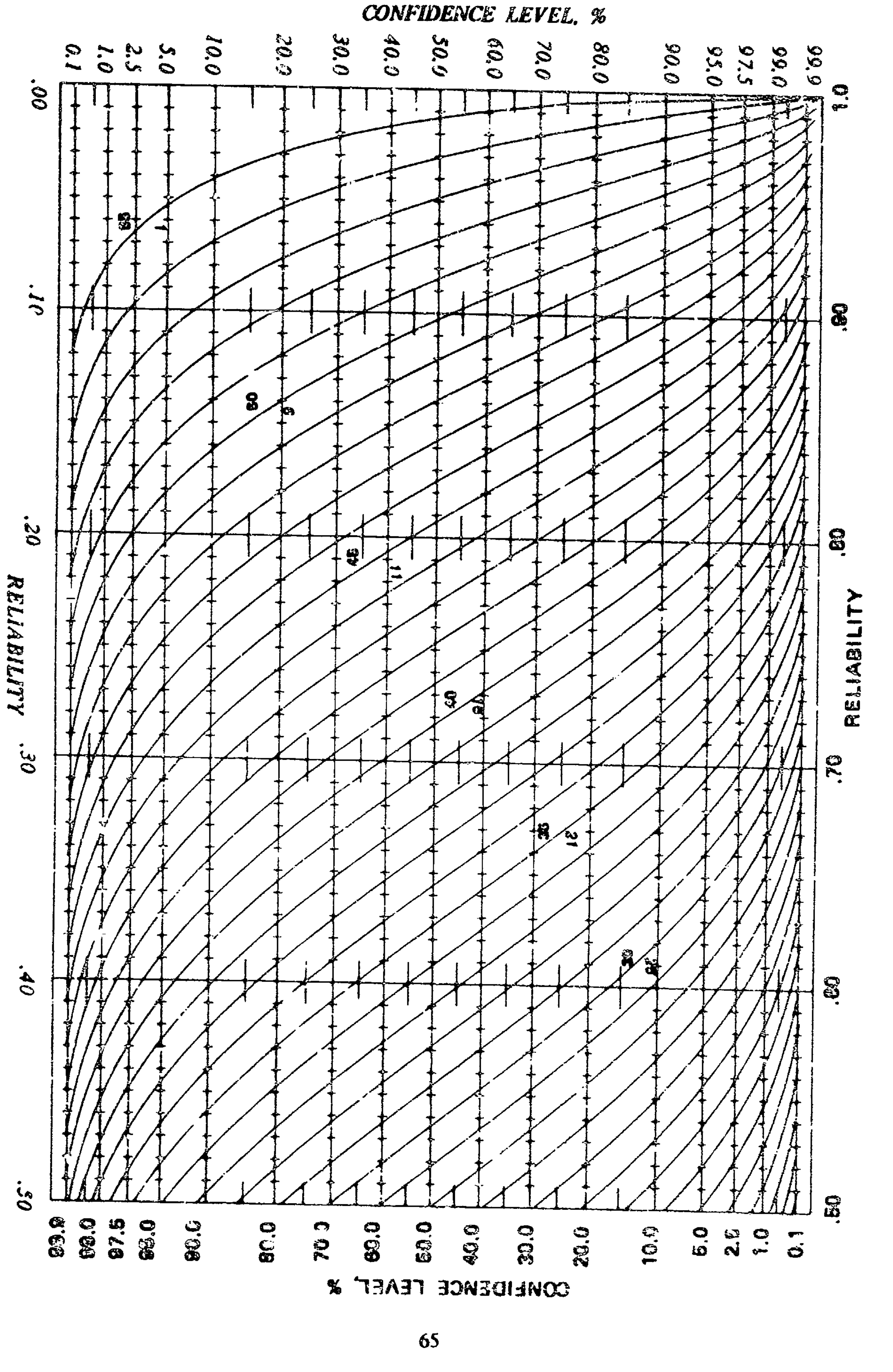

FIGURE 55. Confidence Level and Reliability for N = 55.

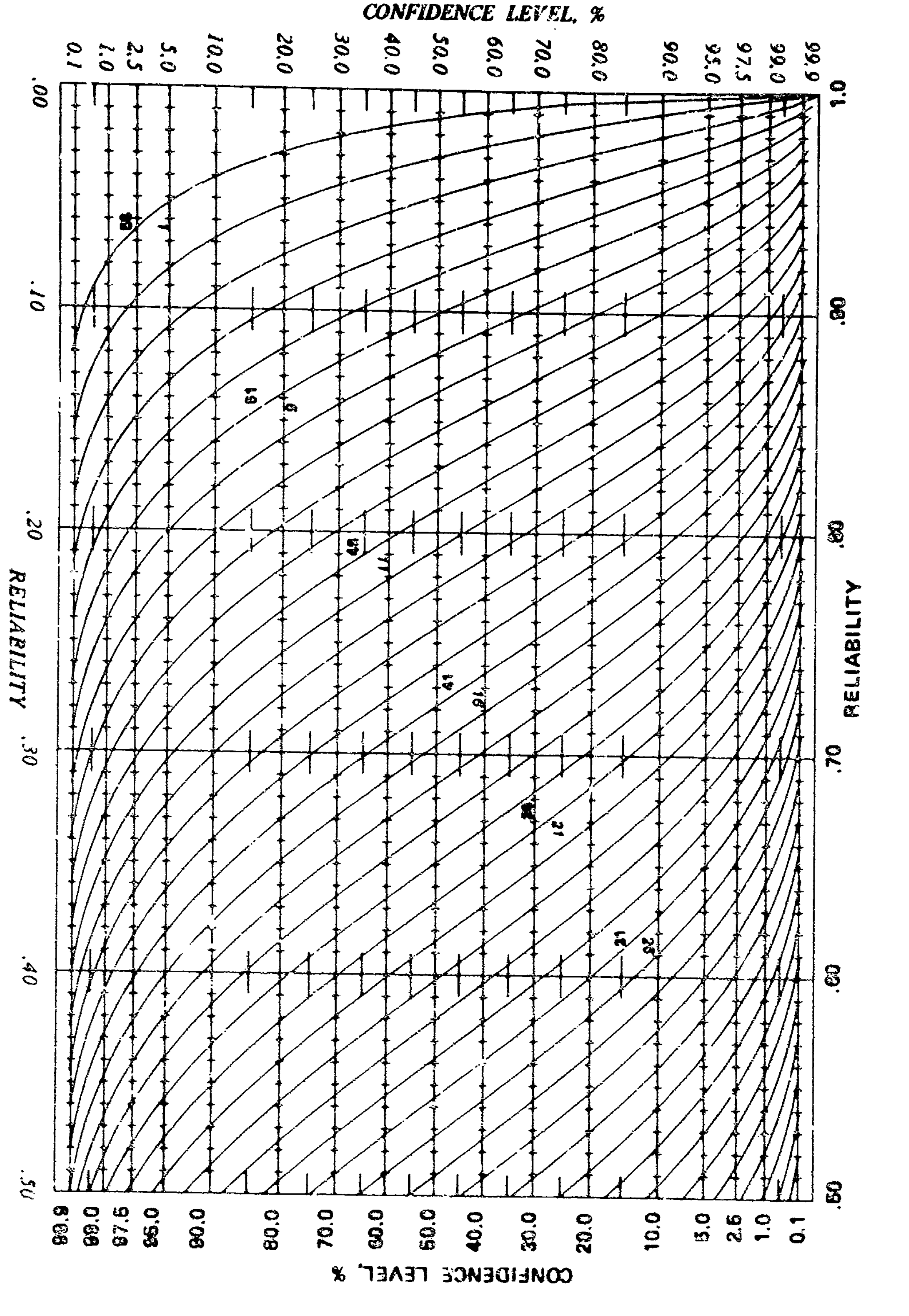

FIGURE 56. Confidence Level and Reliability for N = 56.

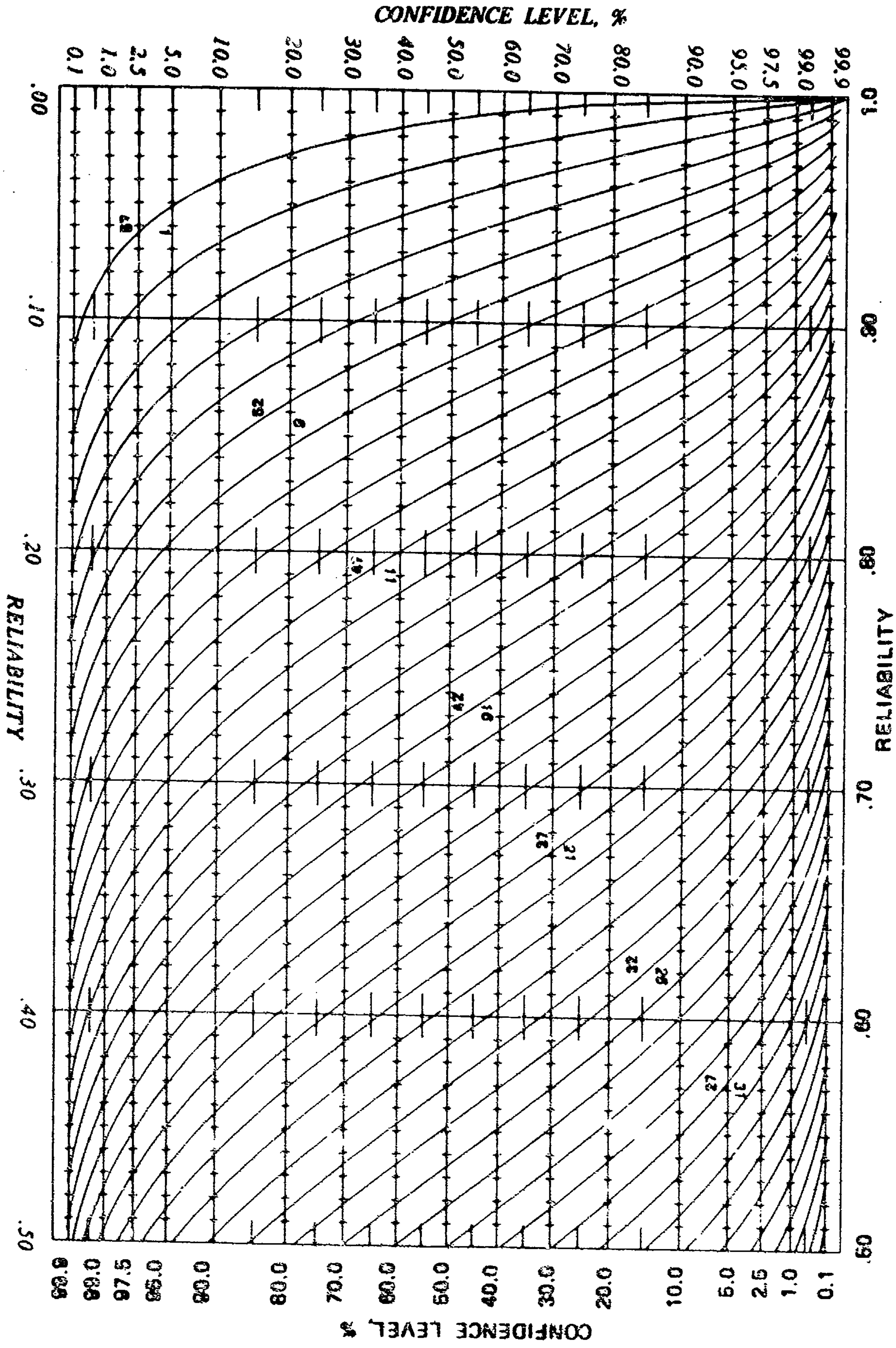

FIGURE 57. Confidence Level and Reliability for N = 57.

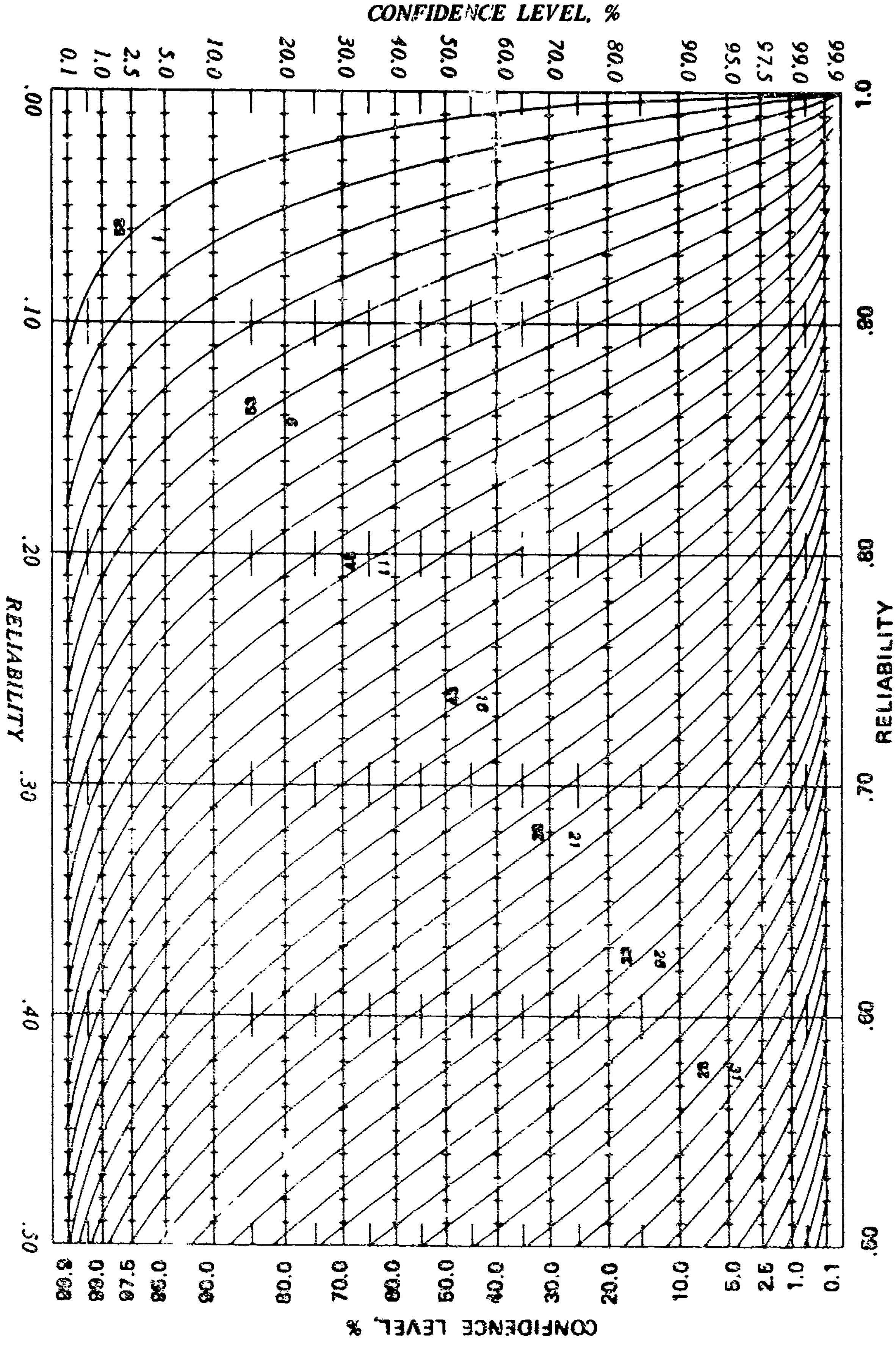

FIGURE 58. Confidence Level and Reliability for N = 58.

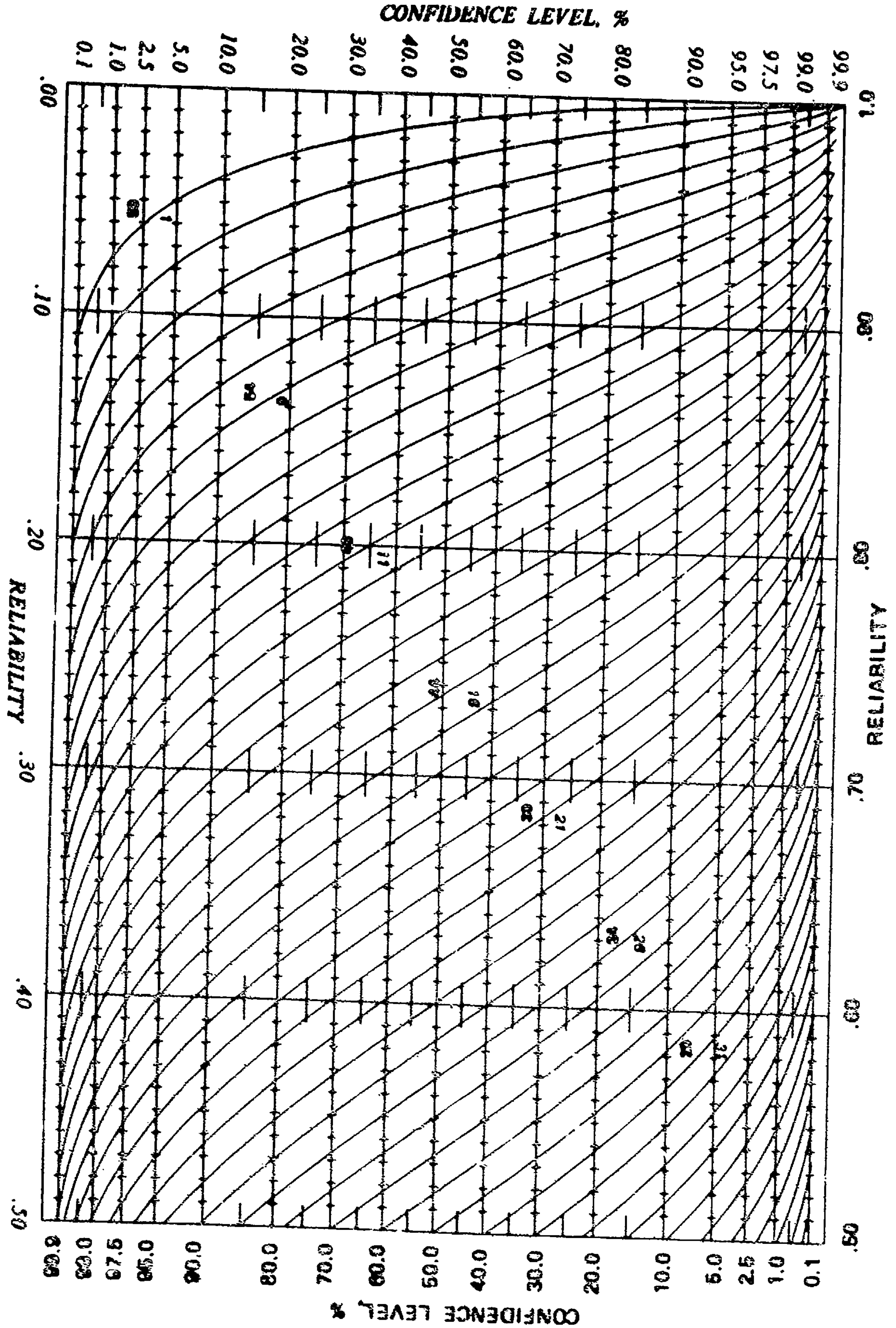

FIGURE 59. C nfidence Level and Reliability for N = 59.

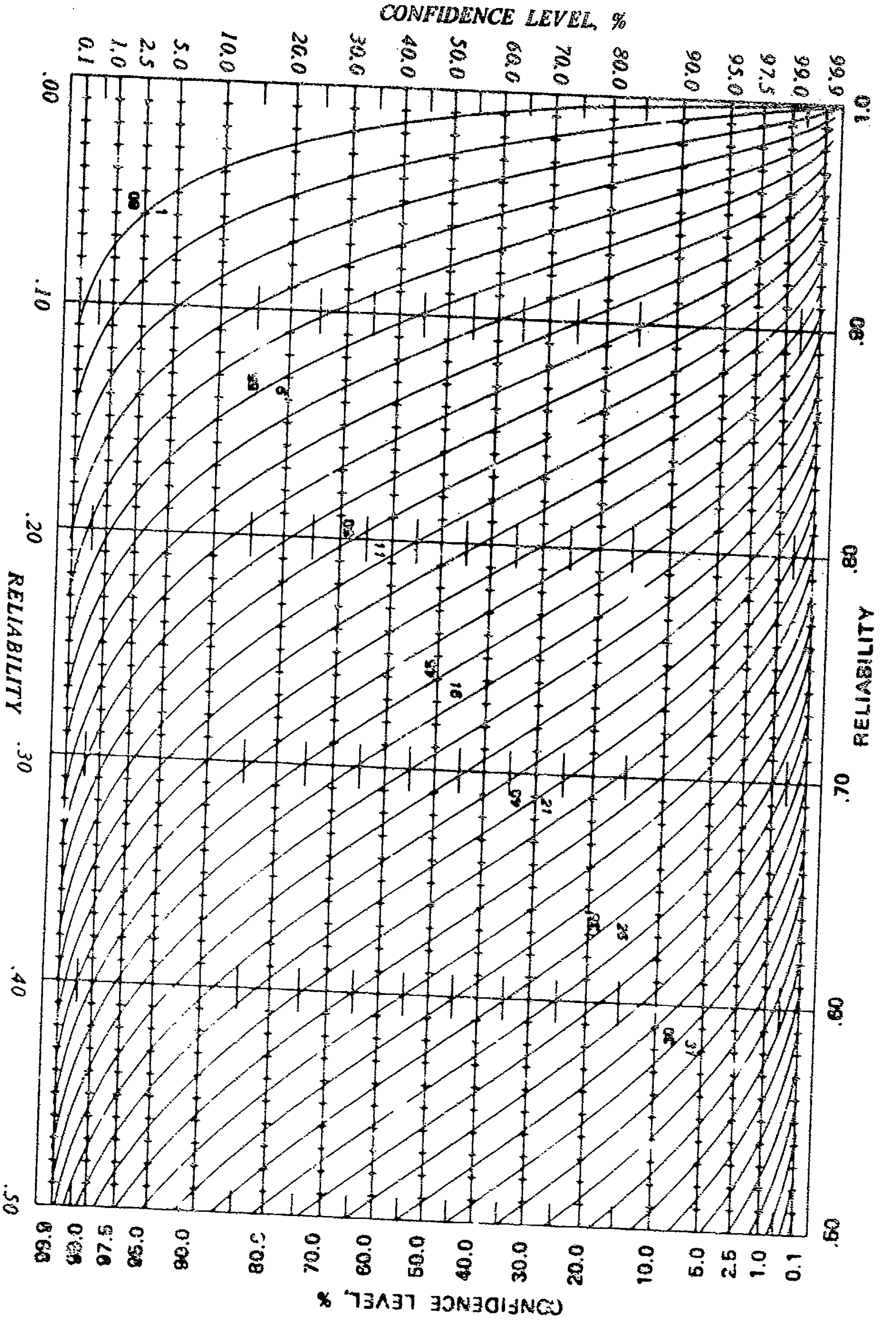

FIGURE 60. Confidence Level and Reliability for N = 60.

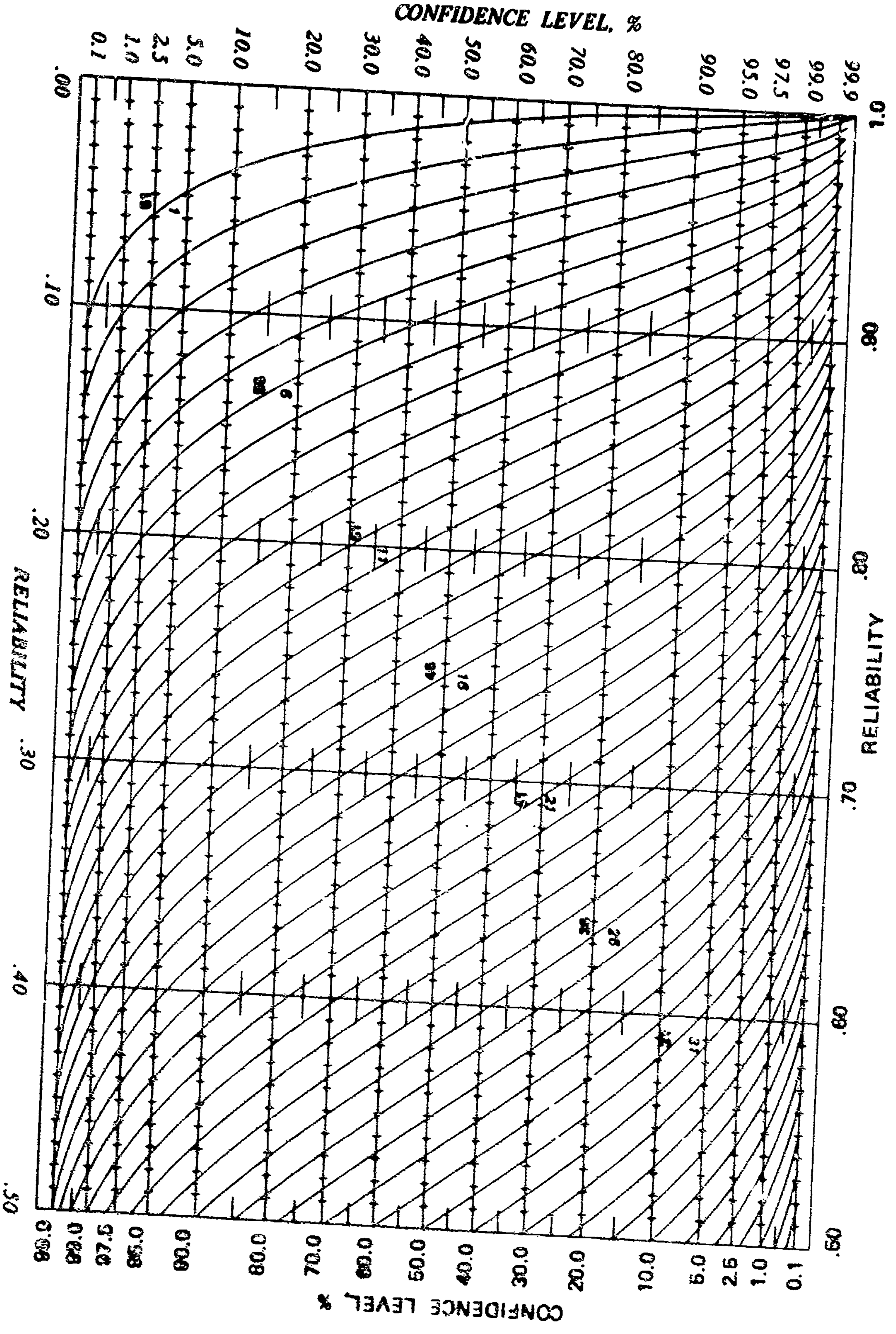

FIGURE 61. Confidence Level and Reliability for N = 61.

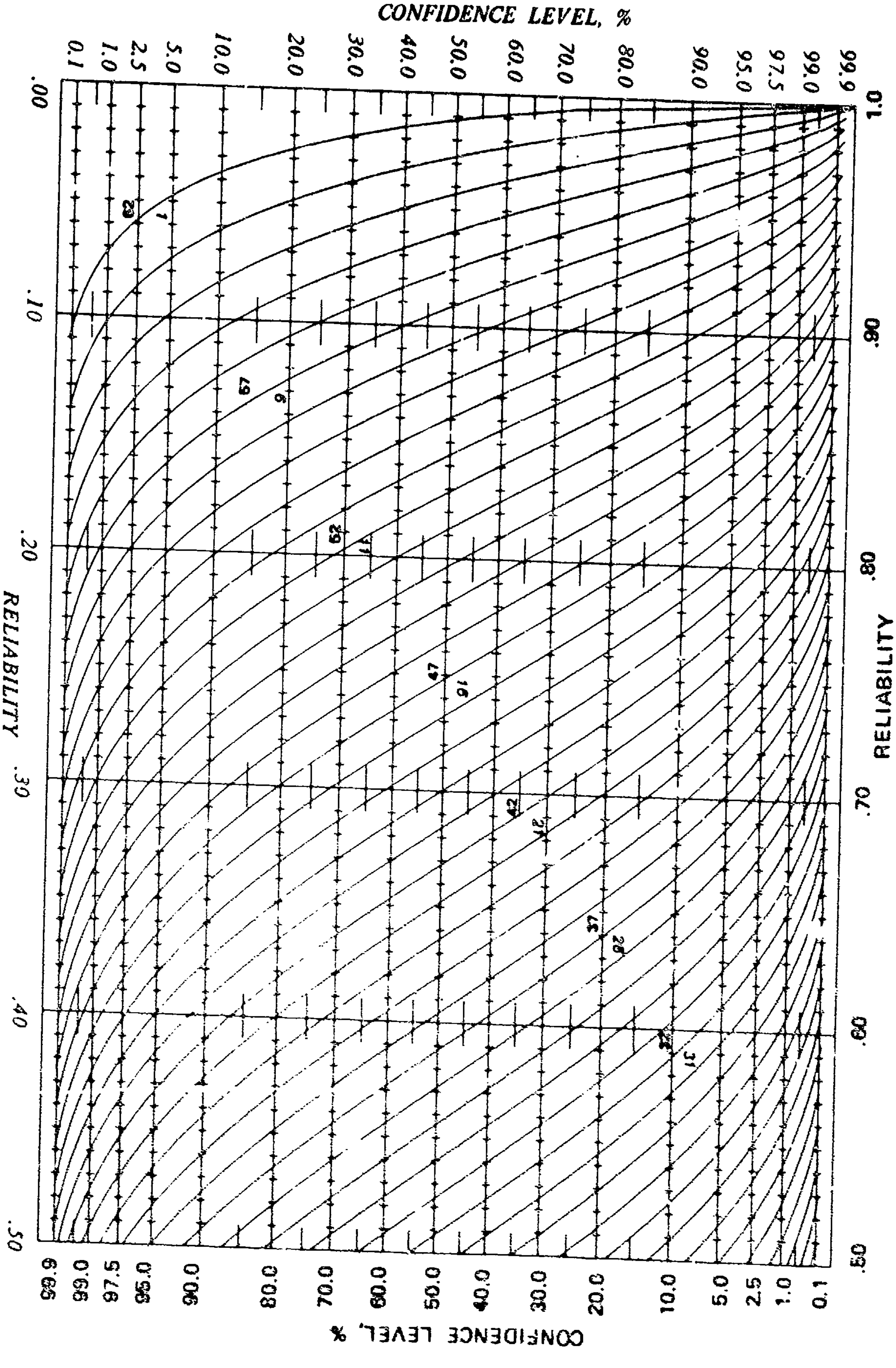

FIGURE 62. Confidence Level and Reliability for N = 62.

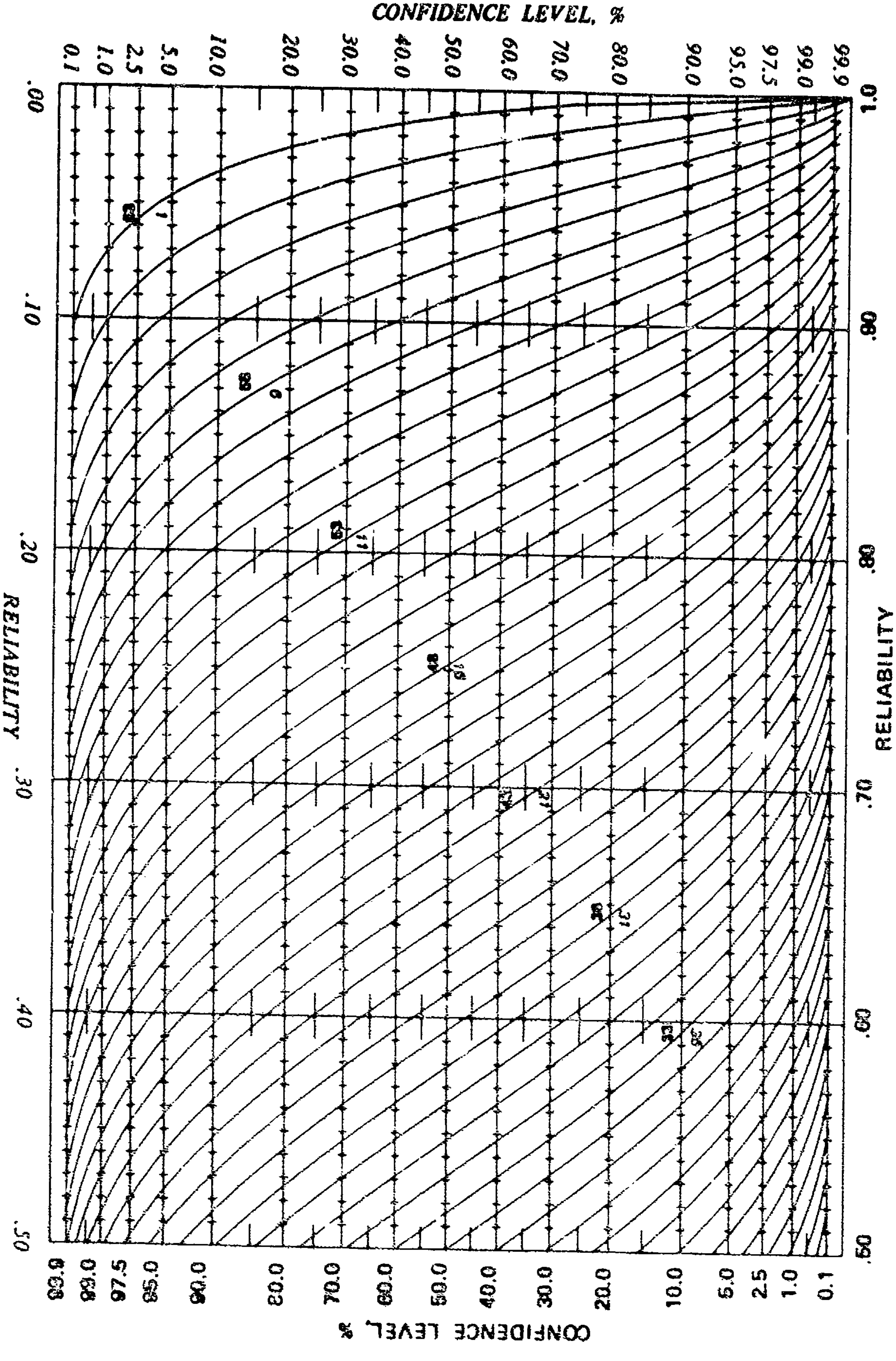

FIGURE 63. Confidence Level and Reliability for N = 63.

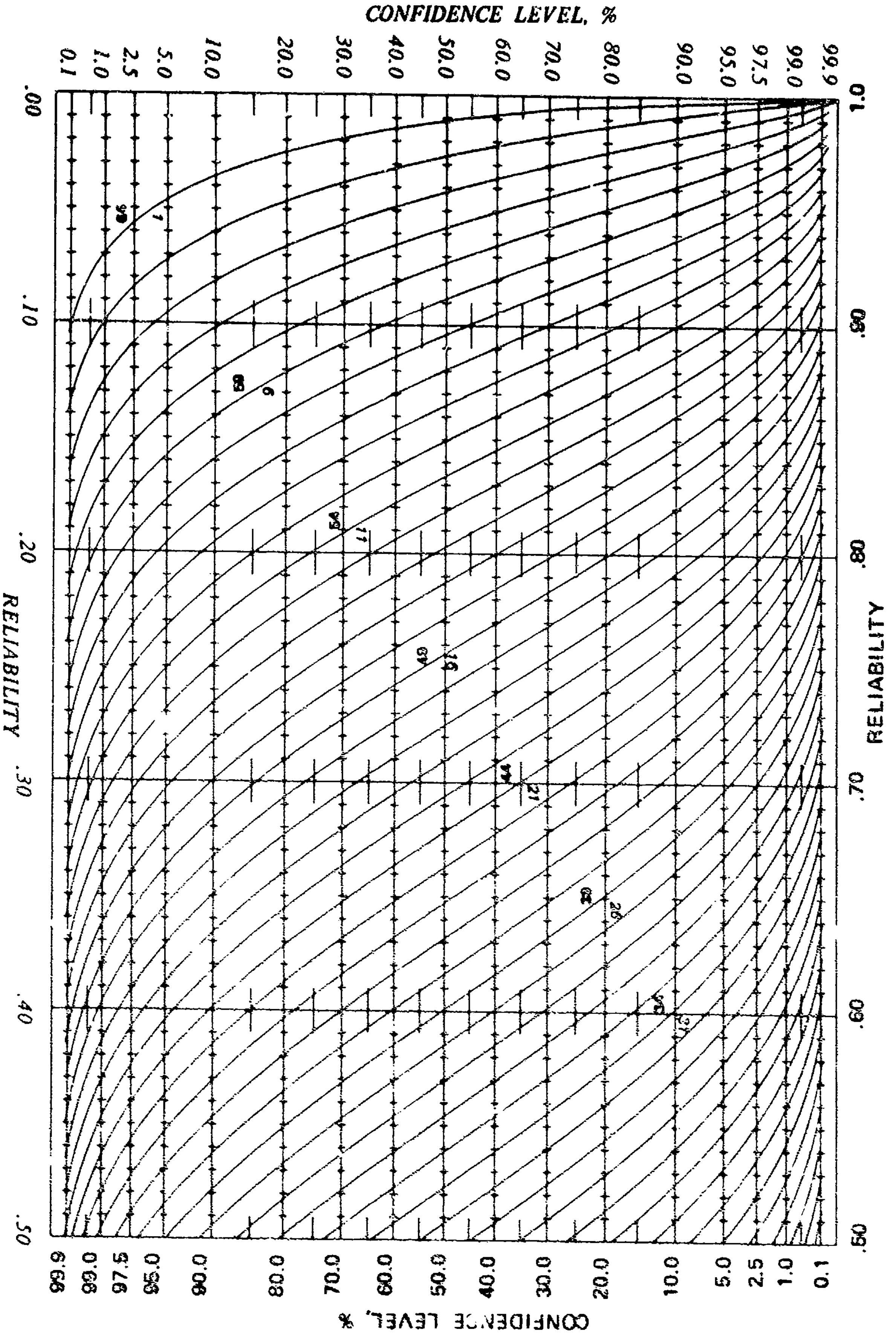

FIGURE 64. Confidence Level and Reliability for N = 64.

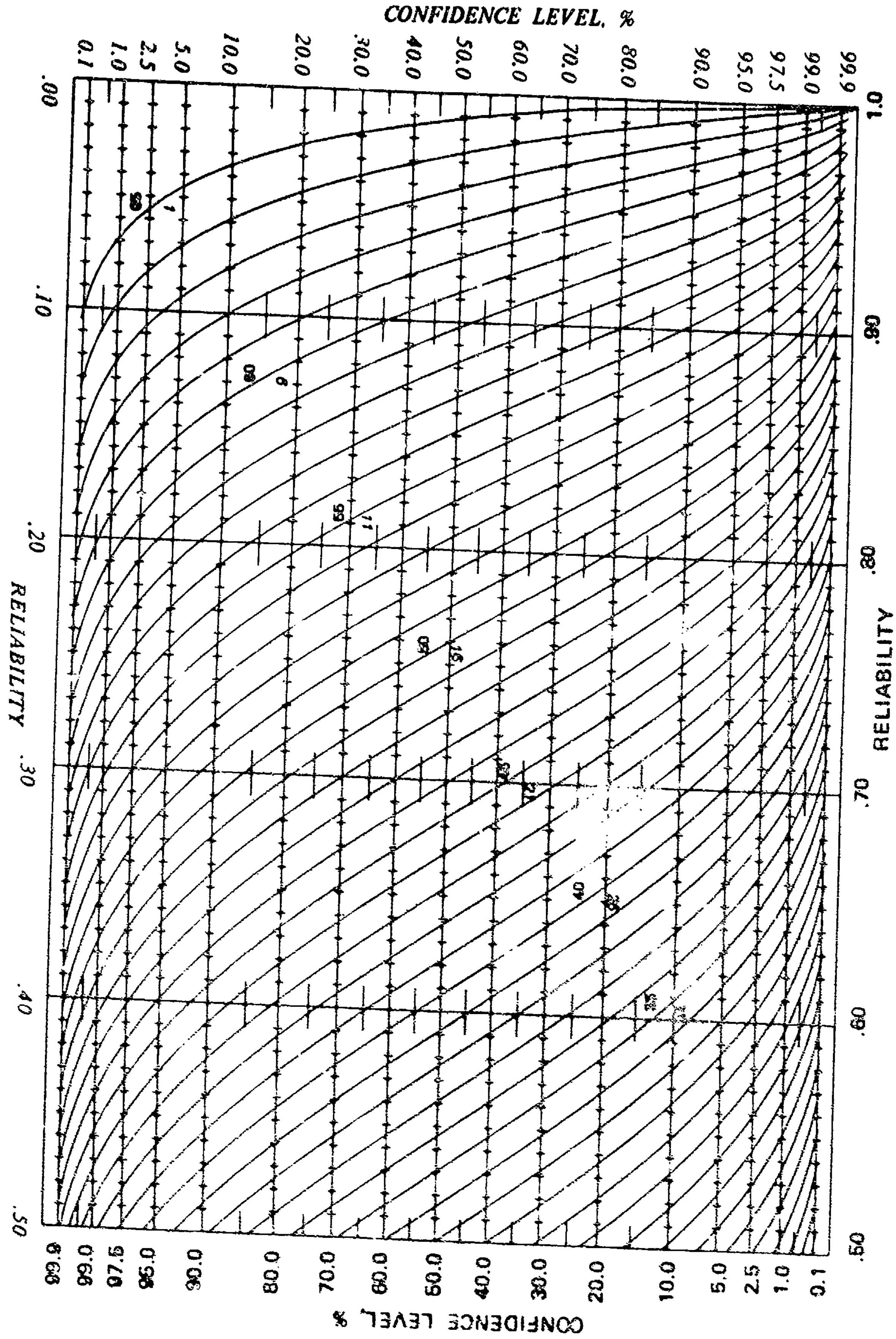

FIGURE 65. Confidence Level and Reliability for N = 65.

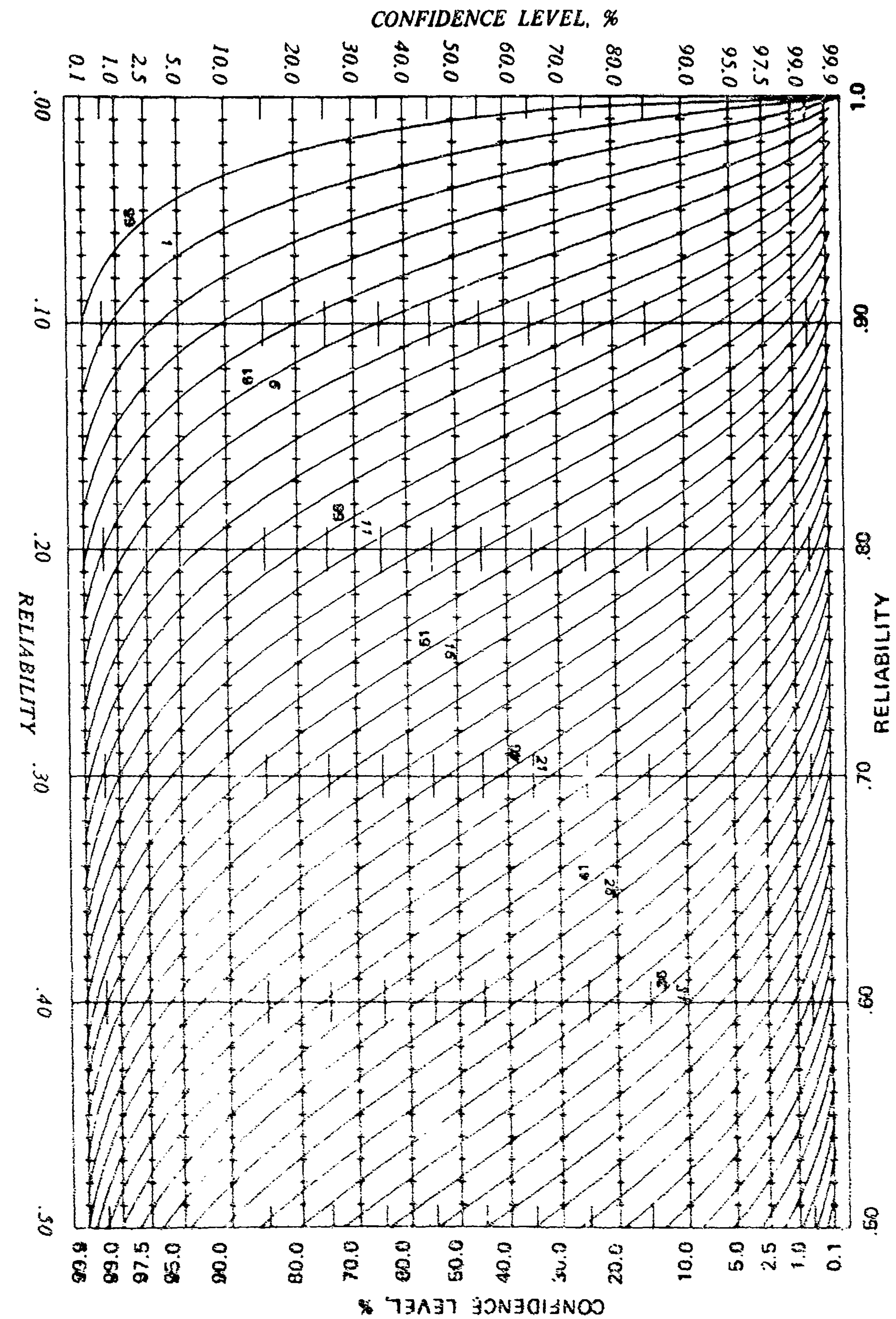

FIGURE 66. Confidence Level and Reliability for N = 66.

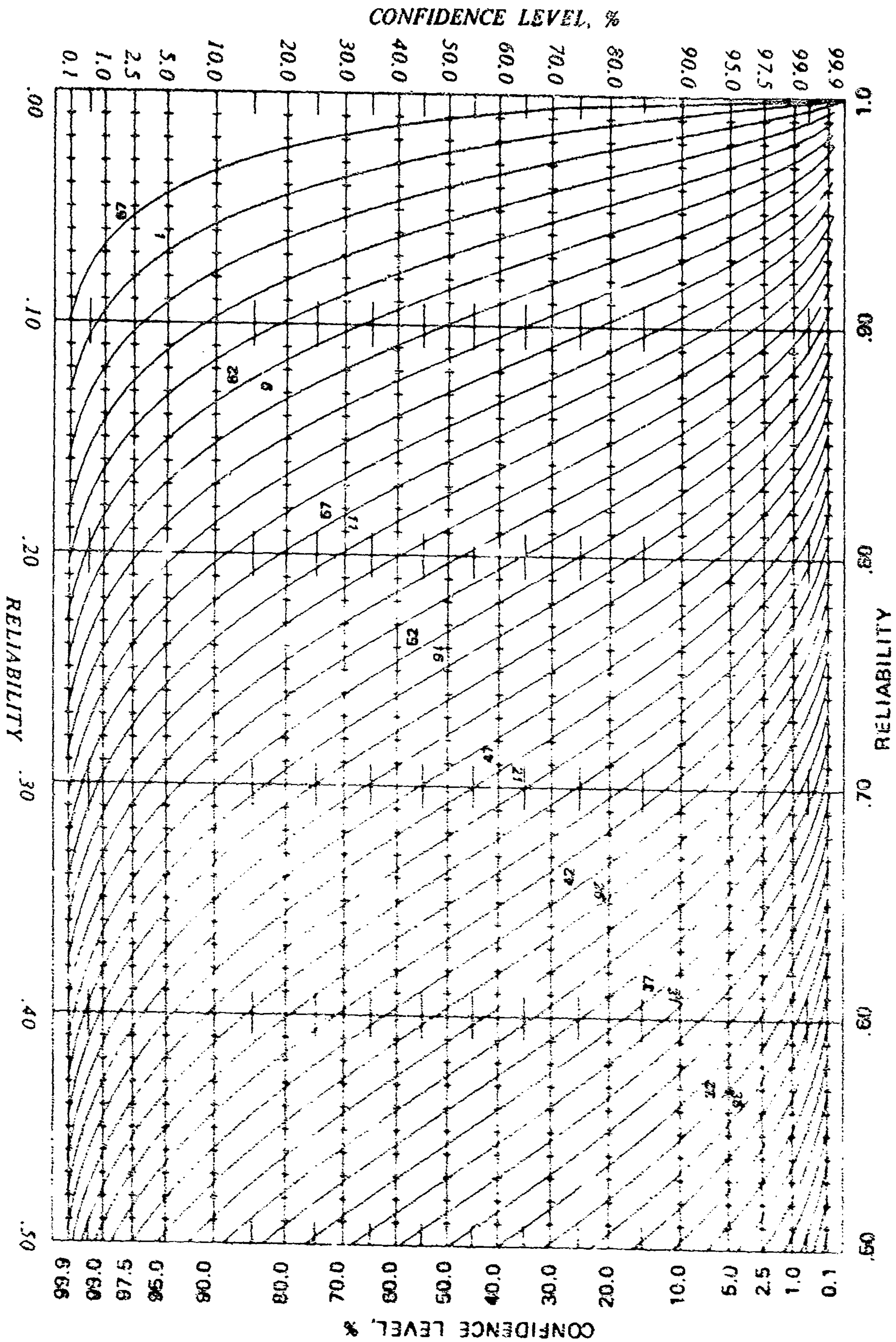

FIGURE 67. Confidence Level and Reliability for N = 67.

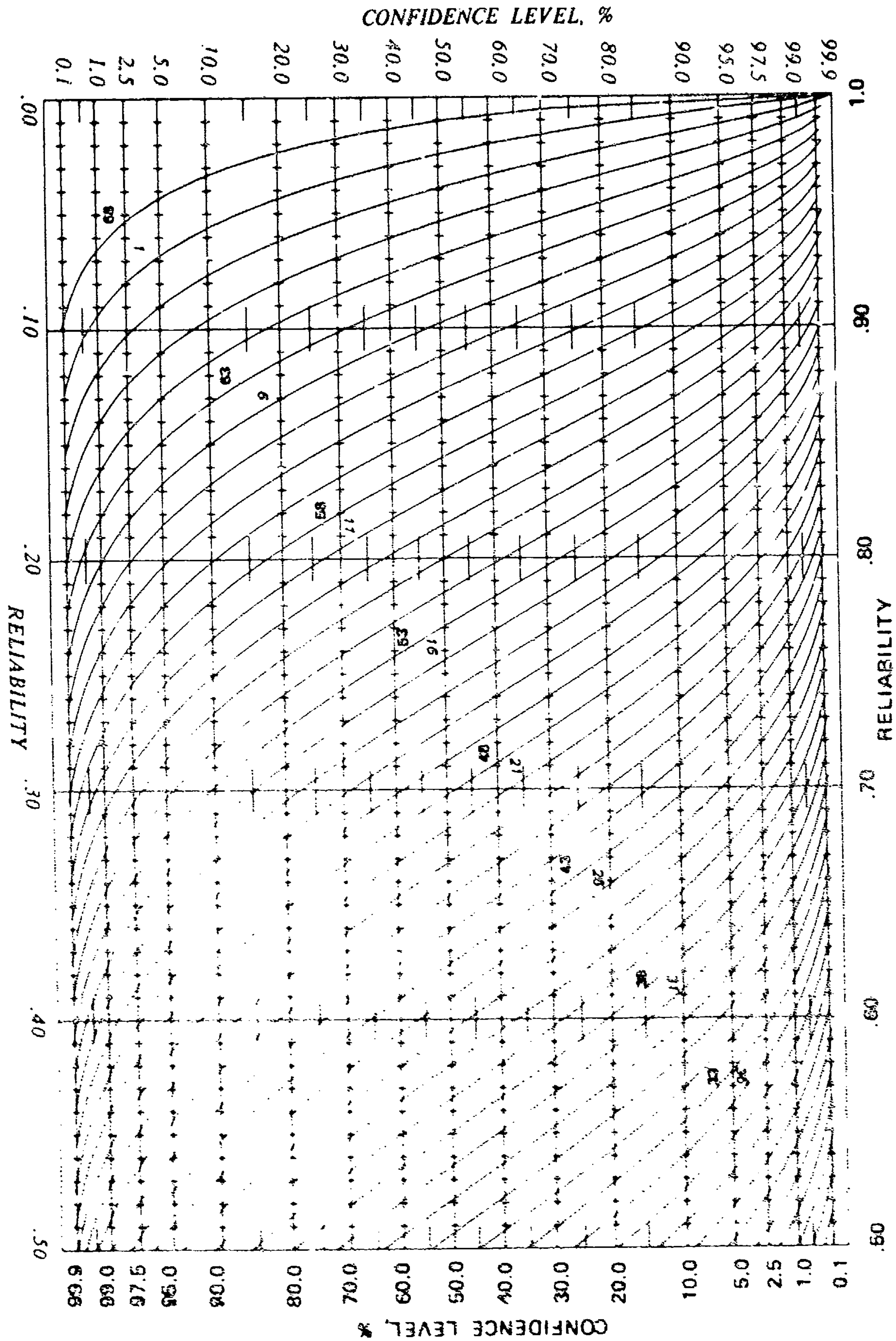

FIGURE 68. Confidence Level and Reliability for N = 68.

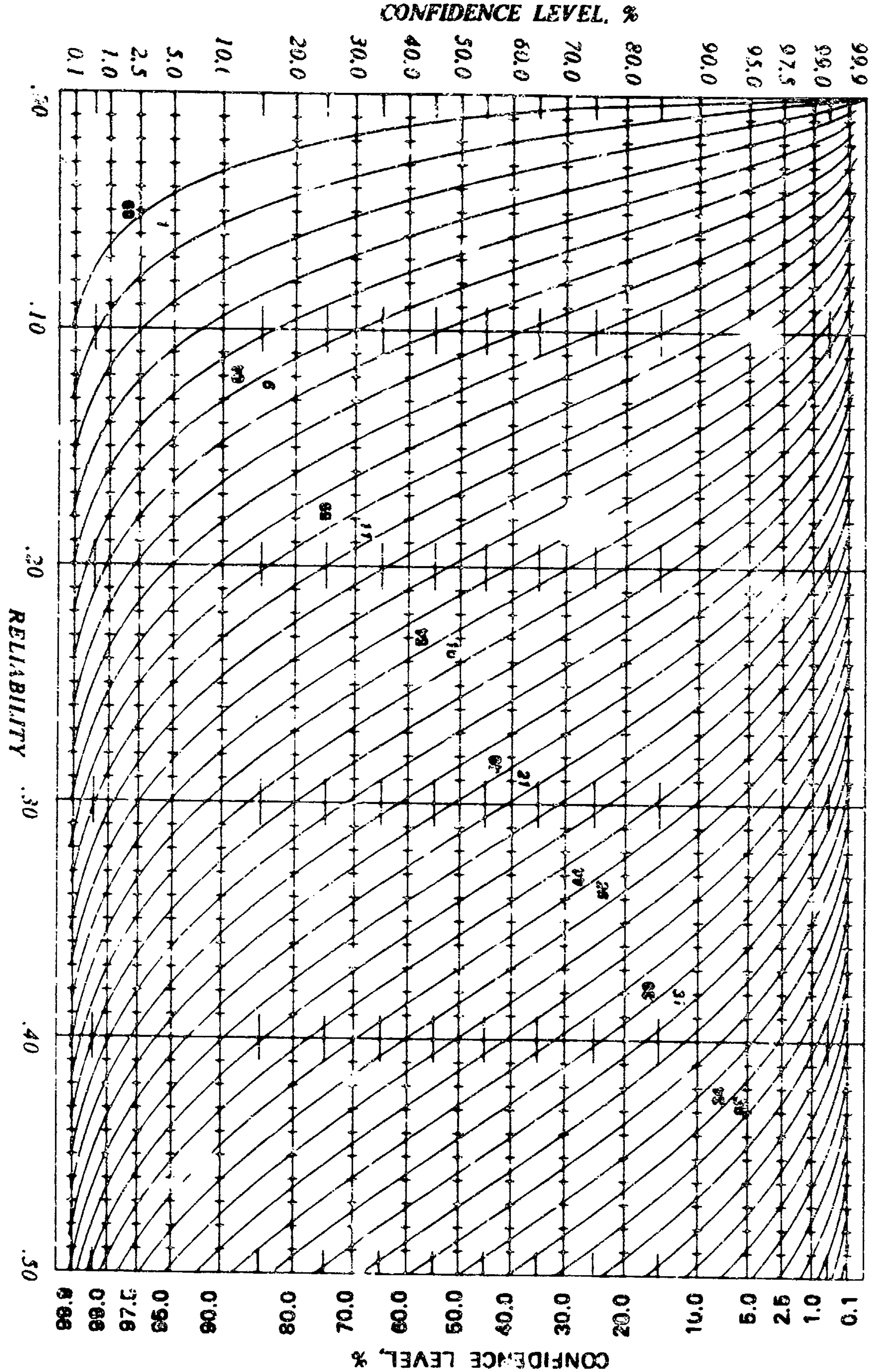

FIGURE 69. Confidence Level and Reliability for N = 69.

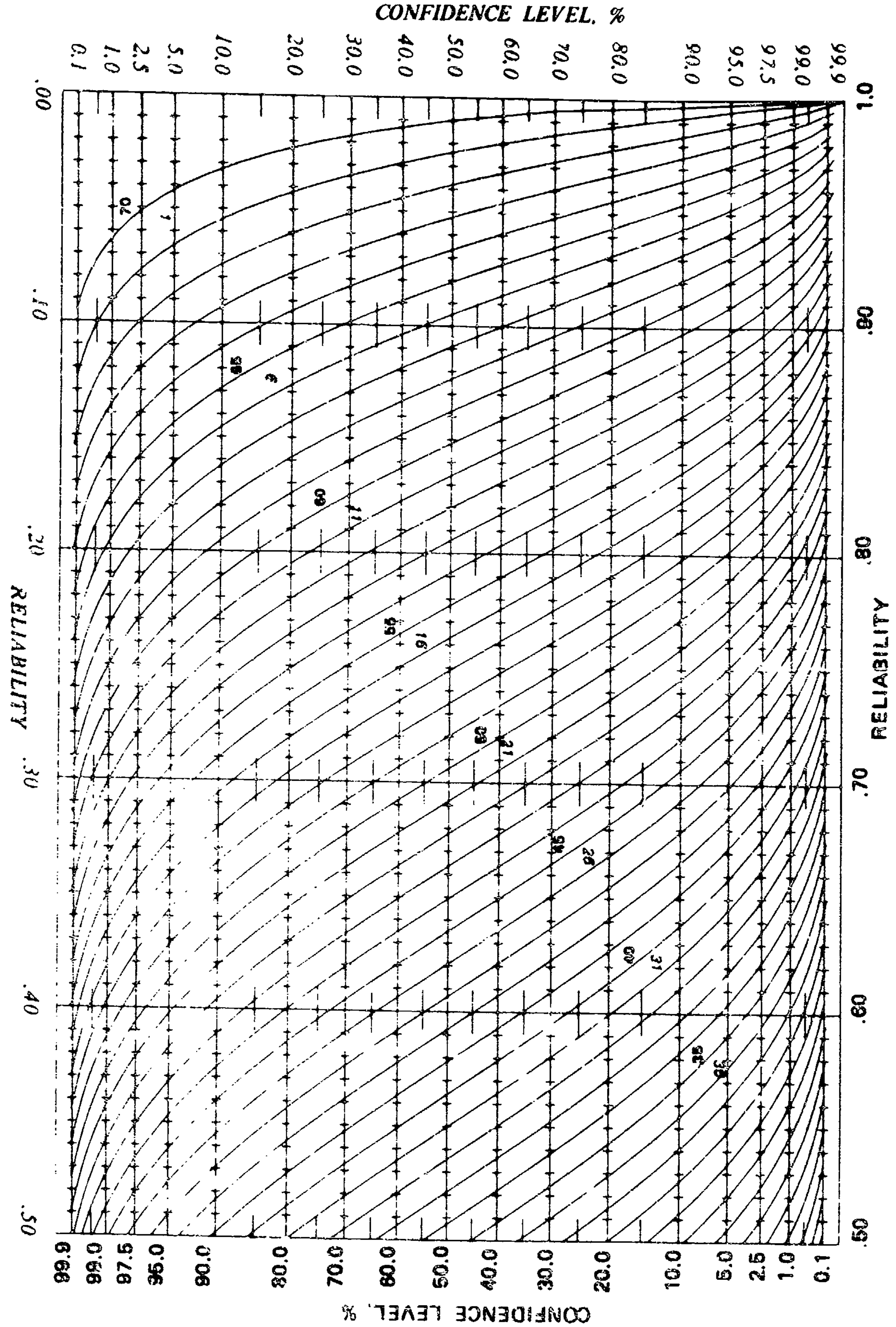

FIGURE 70. Confidence Level and Reliability for N = 70.

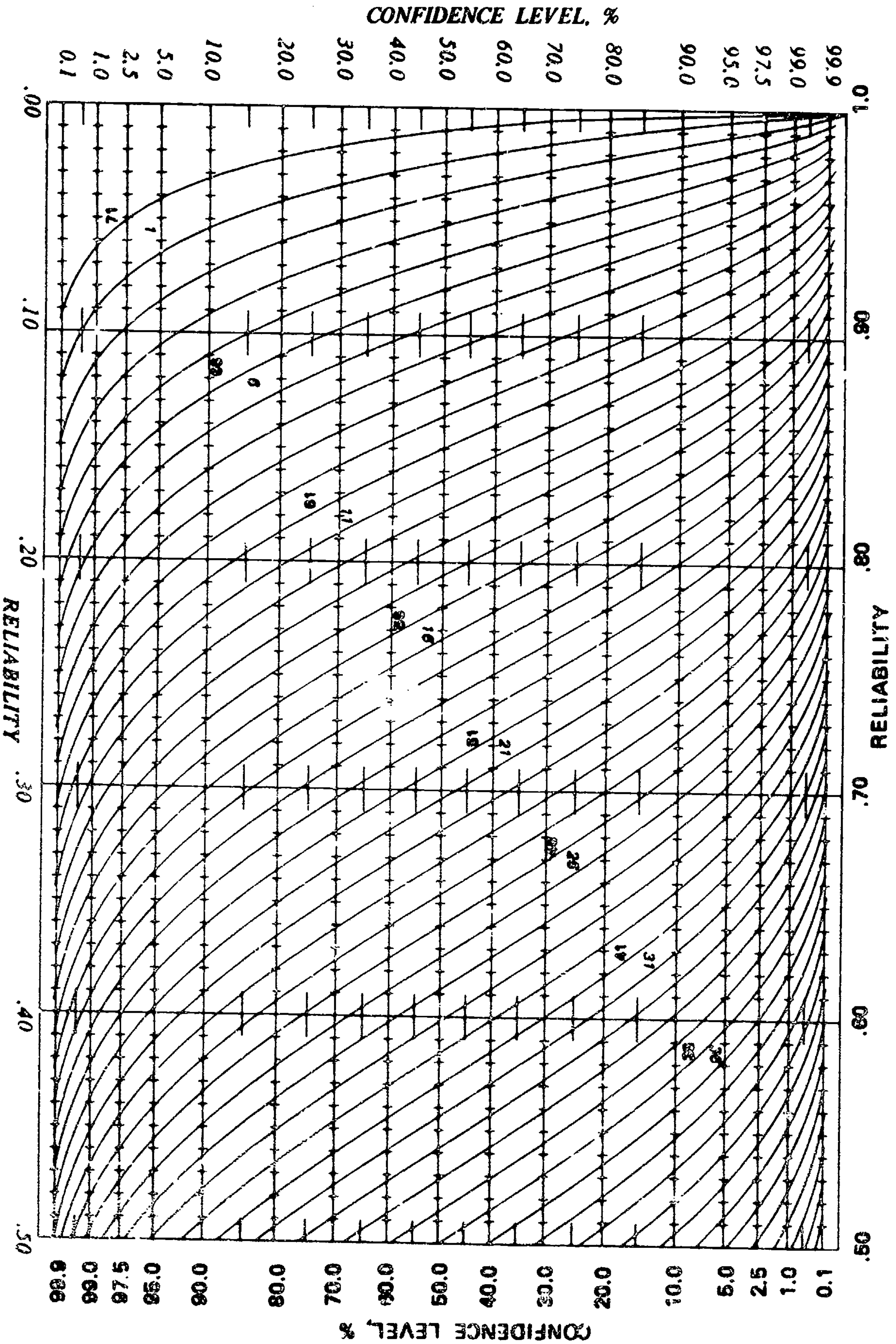

FIGURE 71. Confidence Level and Reliability for N = 71.

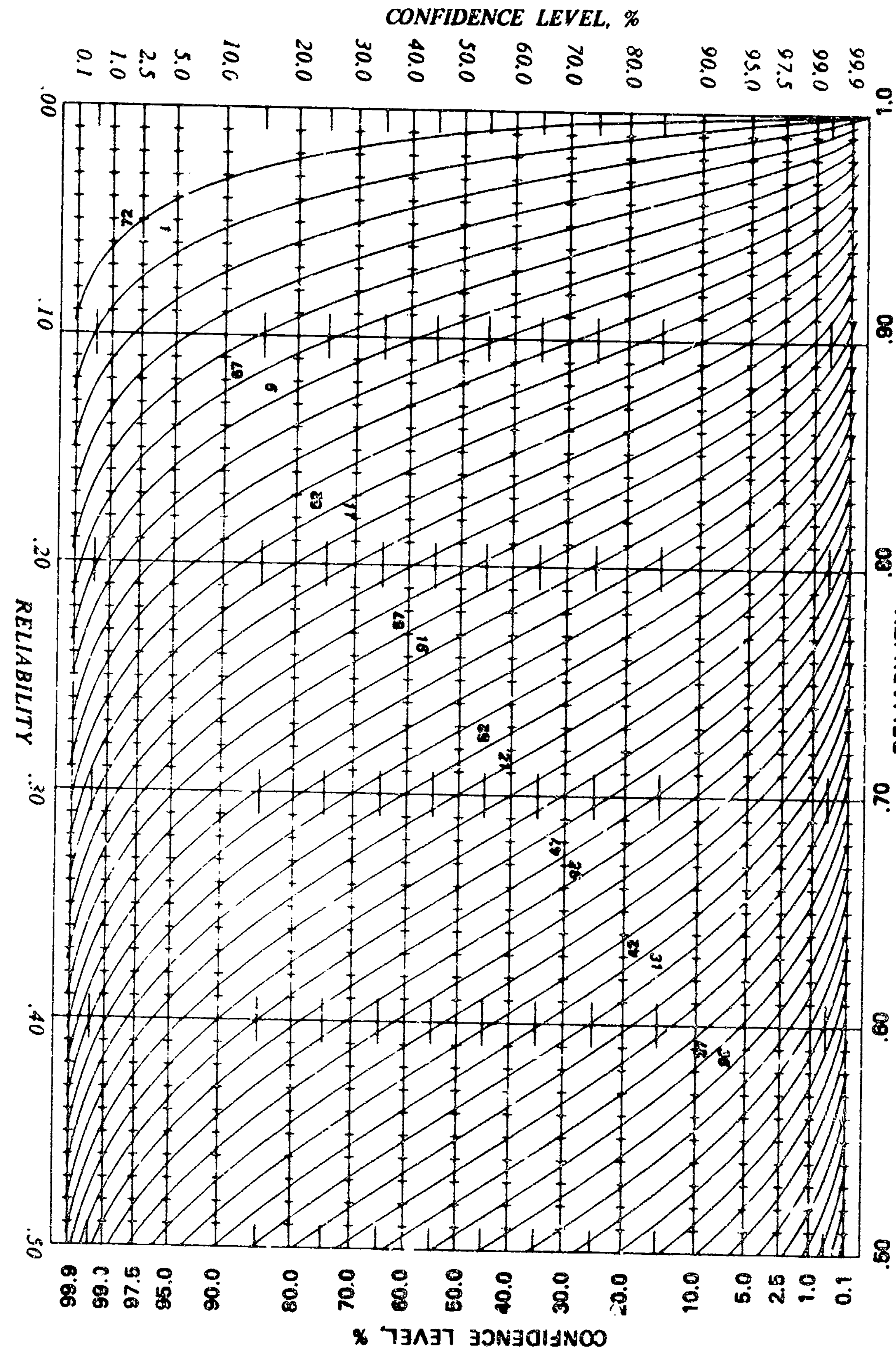

FIGURE 72. Confidence Level and Reliability for N = 72.

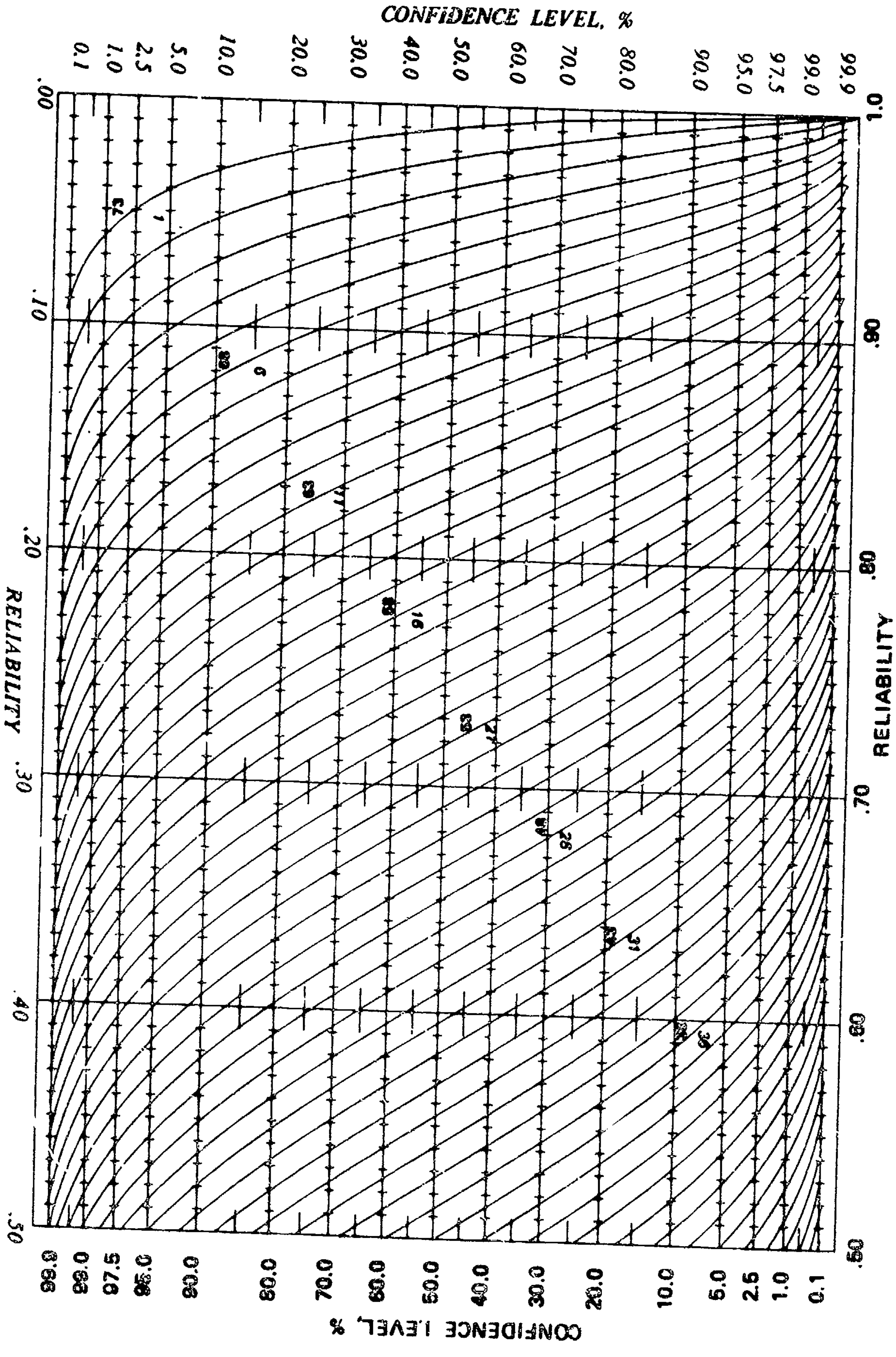

FIGURE 73. Confidence Level and Reliability for N = 73.

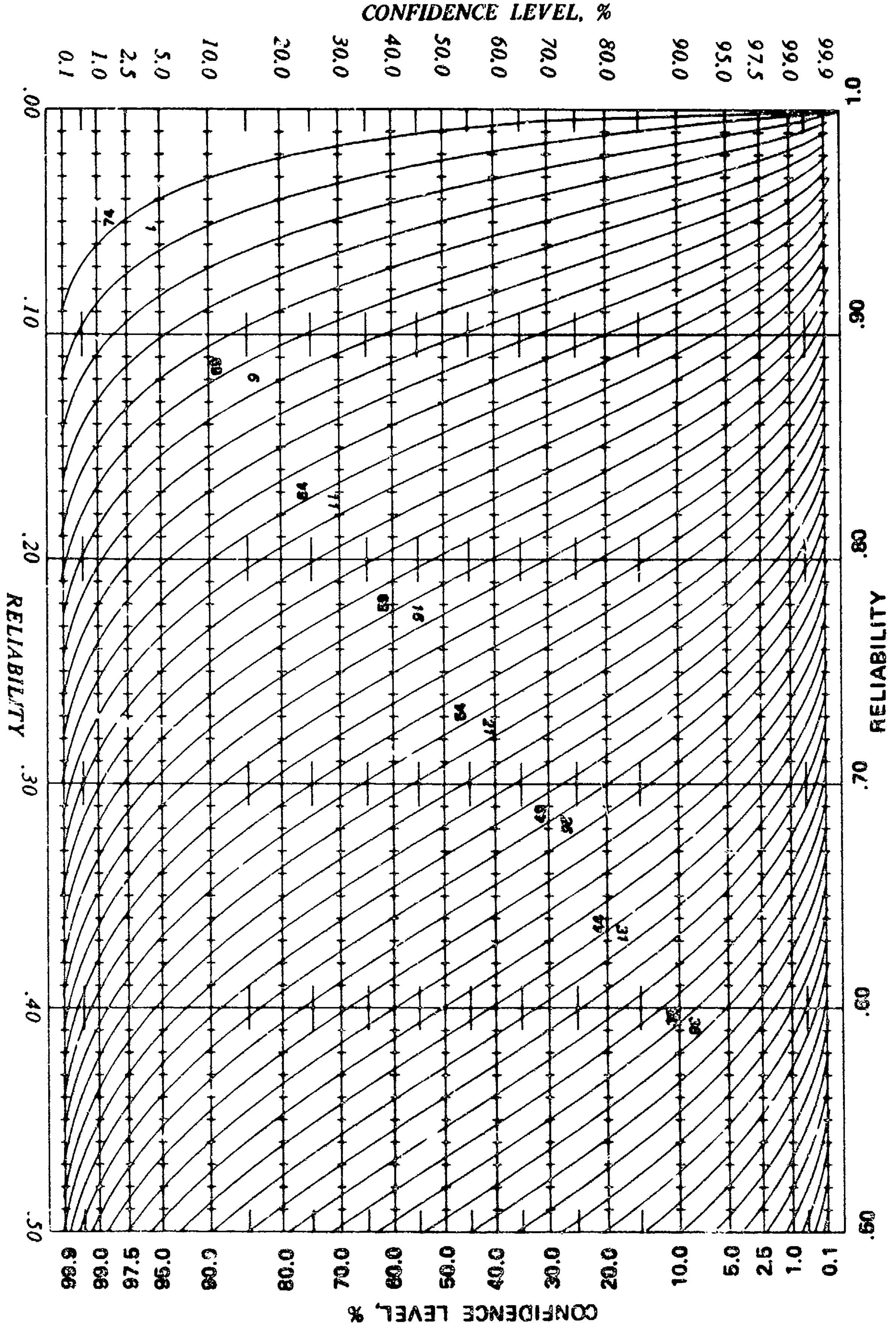

FIGURE 74. Confidence Level and Reliability for N = 74.

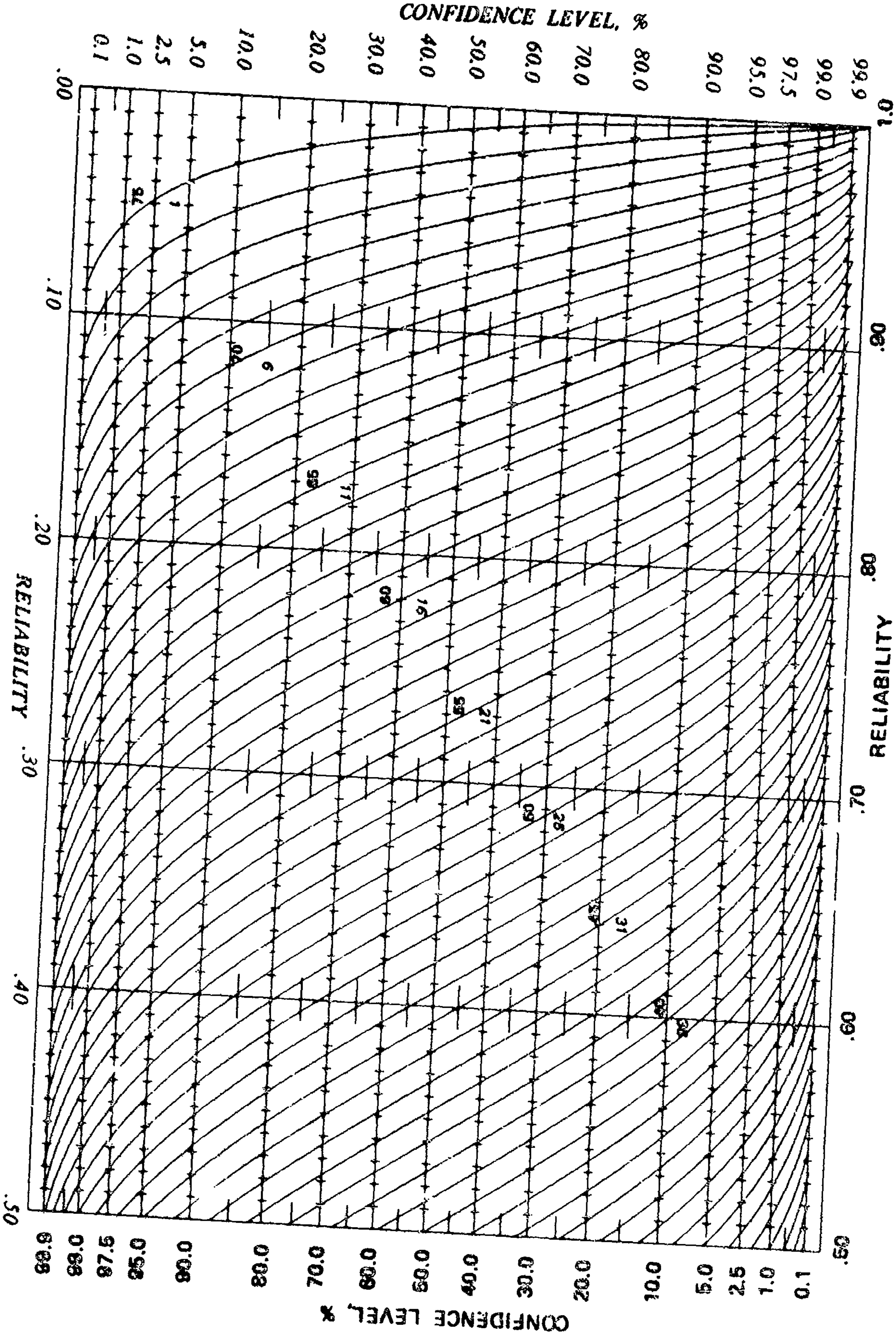

FIGURE 75. Confidence Level and Reliability for N = 75.

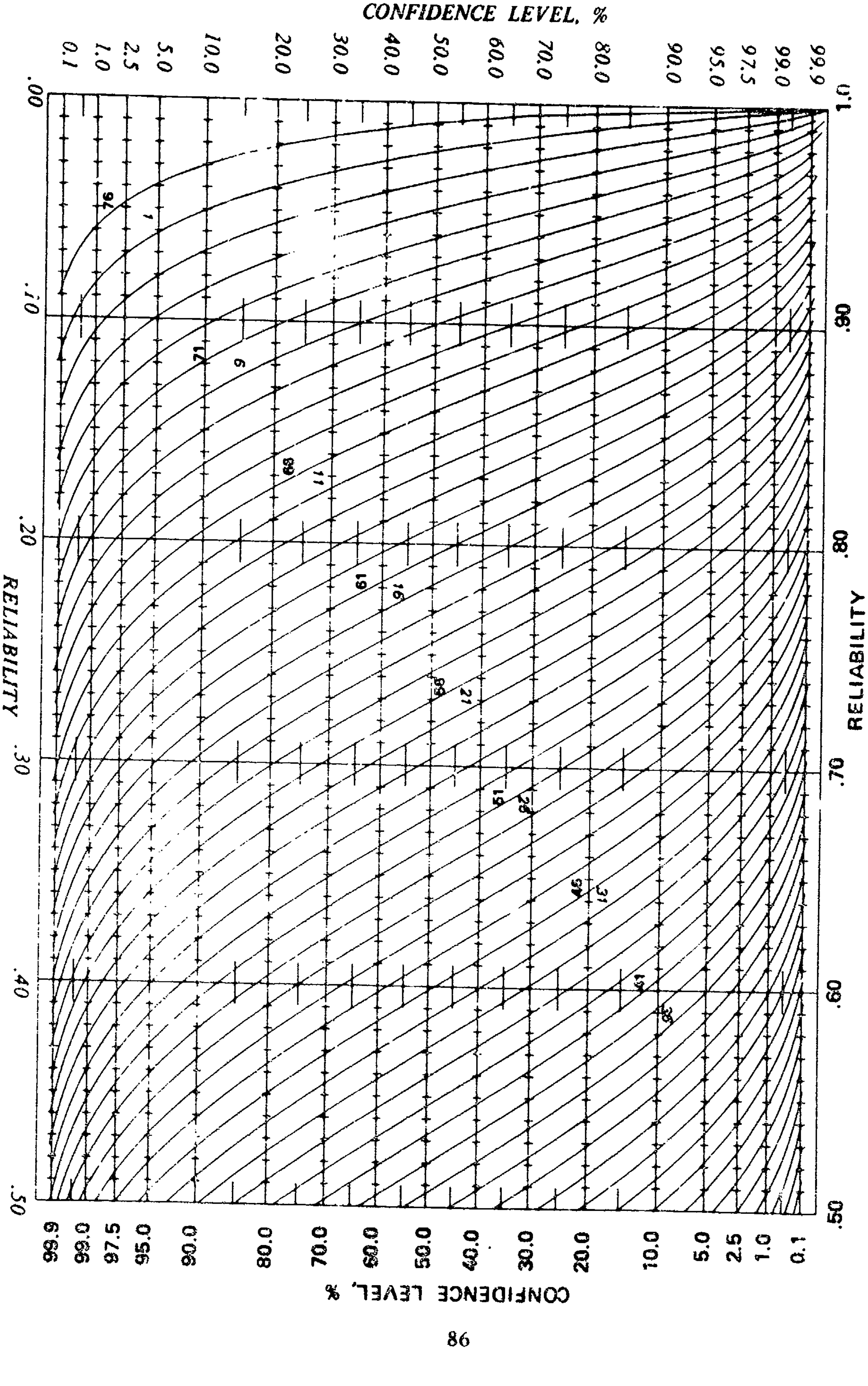

FIGURE 76. Confidence Level and Reliability for N = 76.

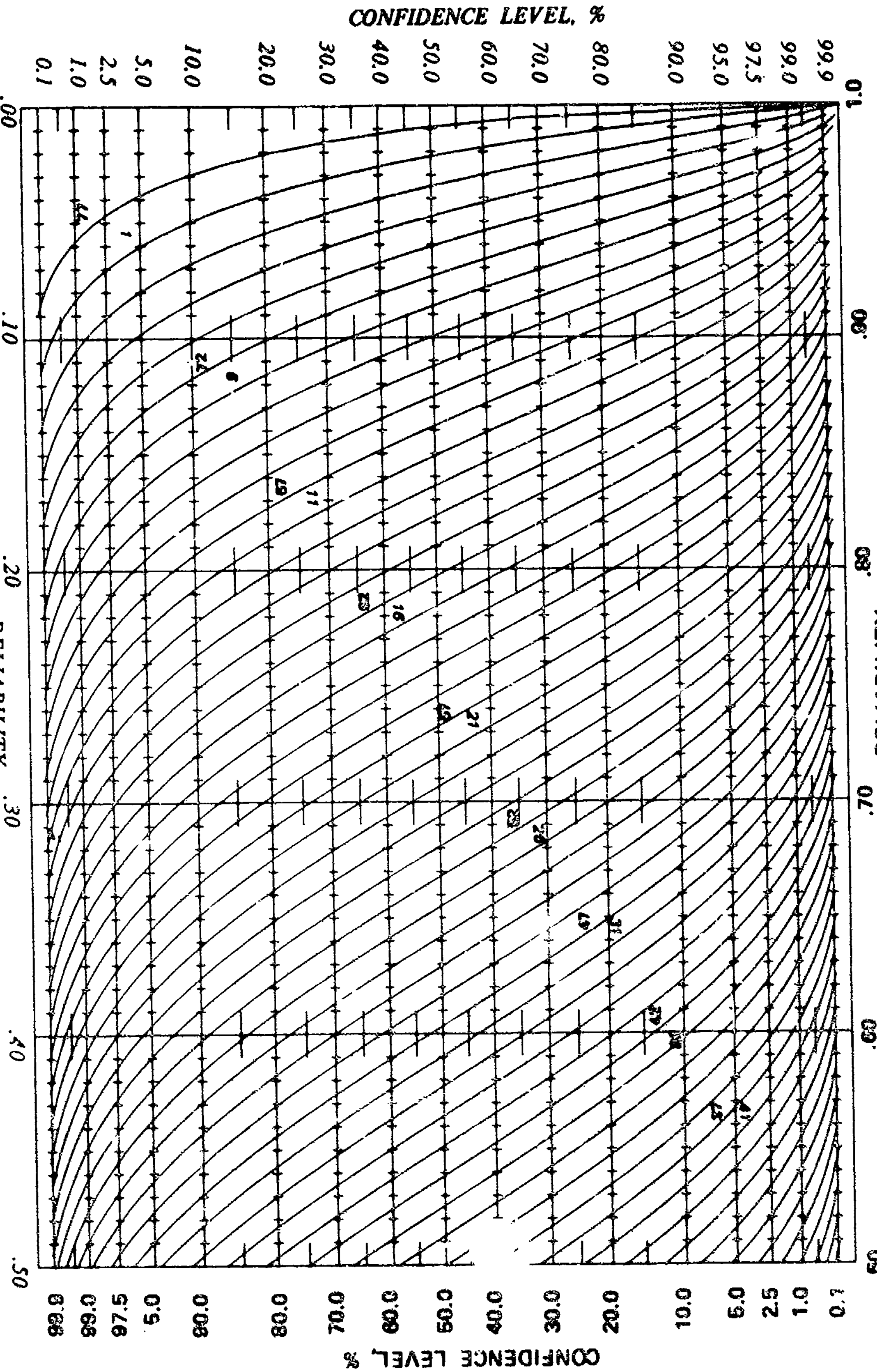

FIGURE 77. Confidence Level and Reliability for N = 77.

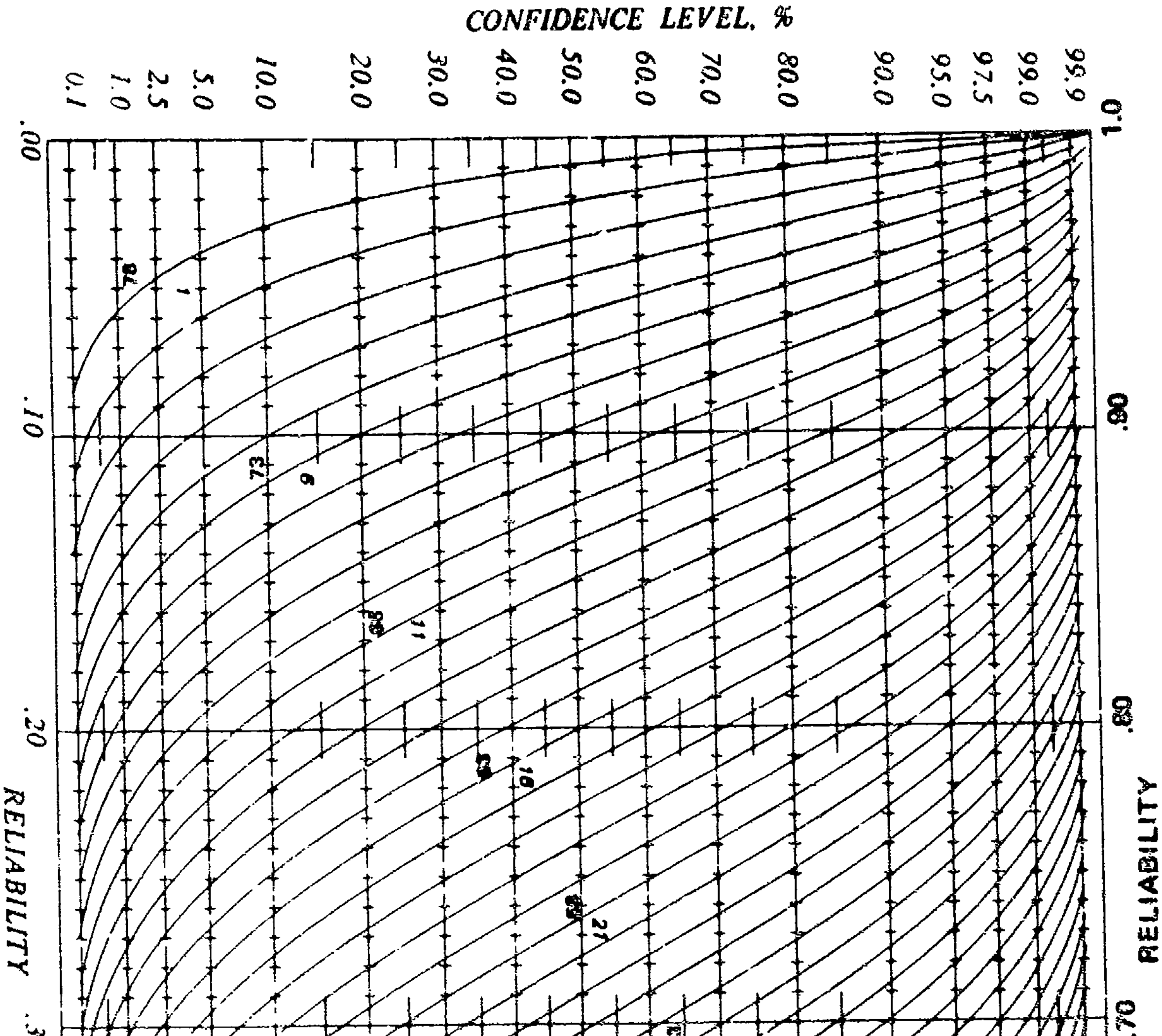

FIGURE 78. Confidence Level and Reliability for N = 78.

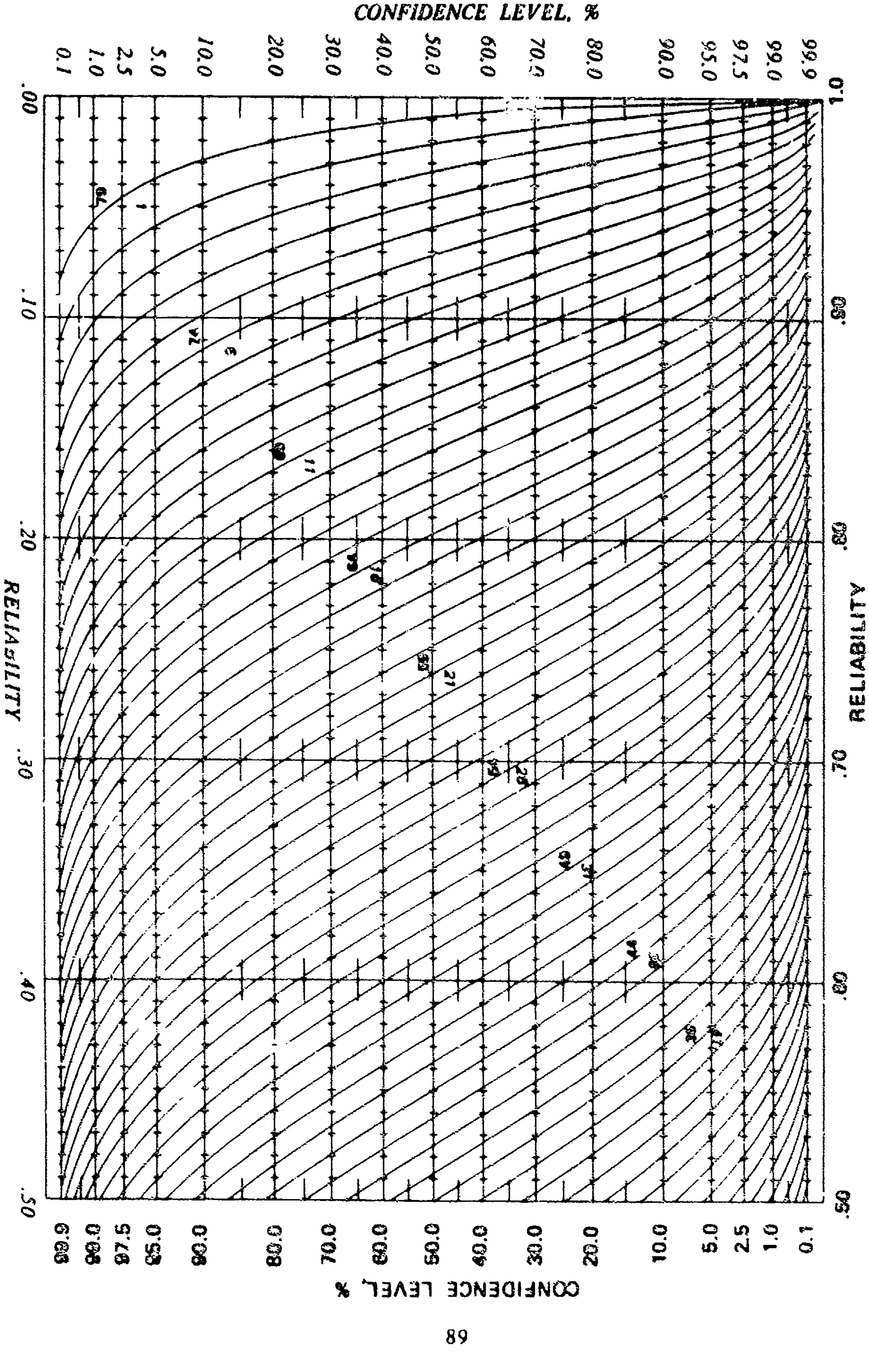

FIGURE 79. Confidence Level and Reliability for N = 79.

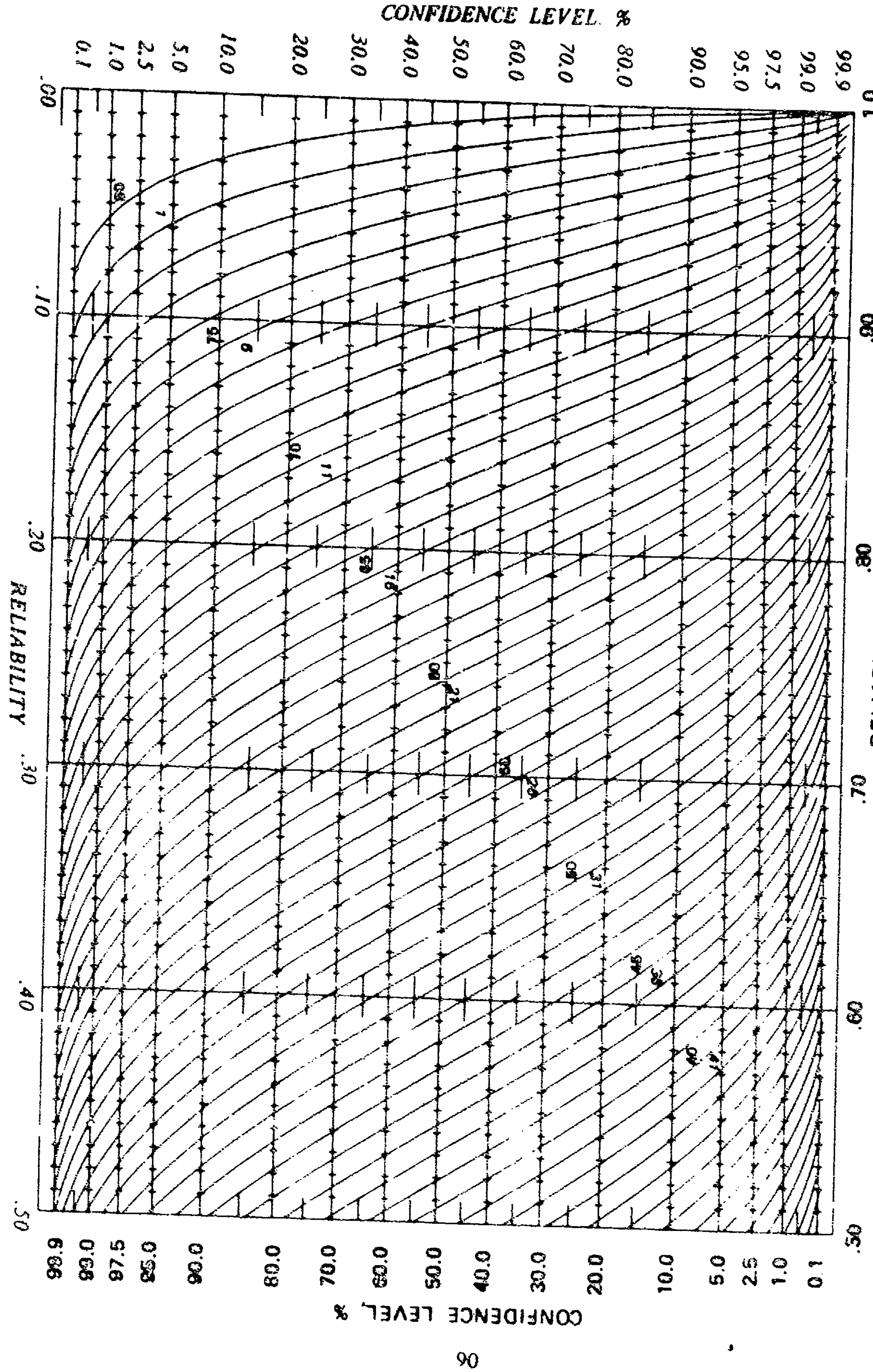

FIGURE 80. Confidence Level and Reliability for N = 80.

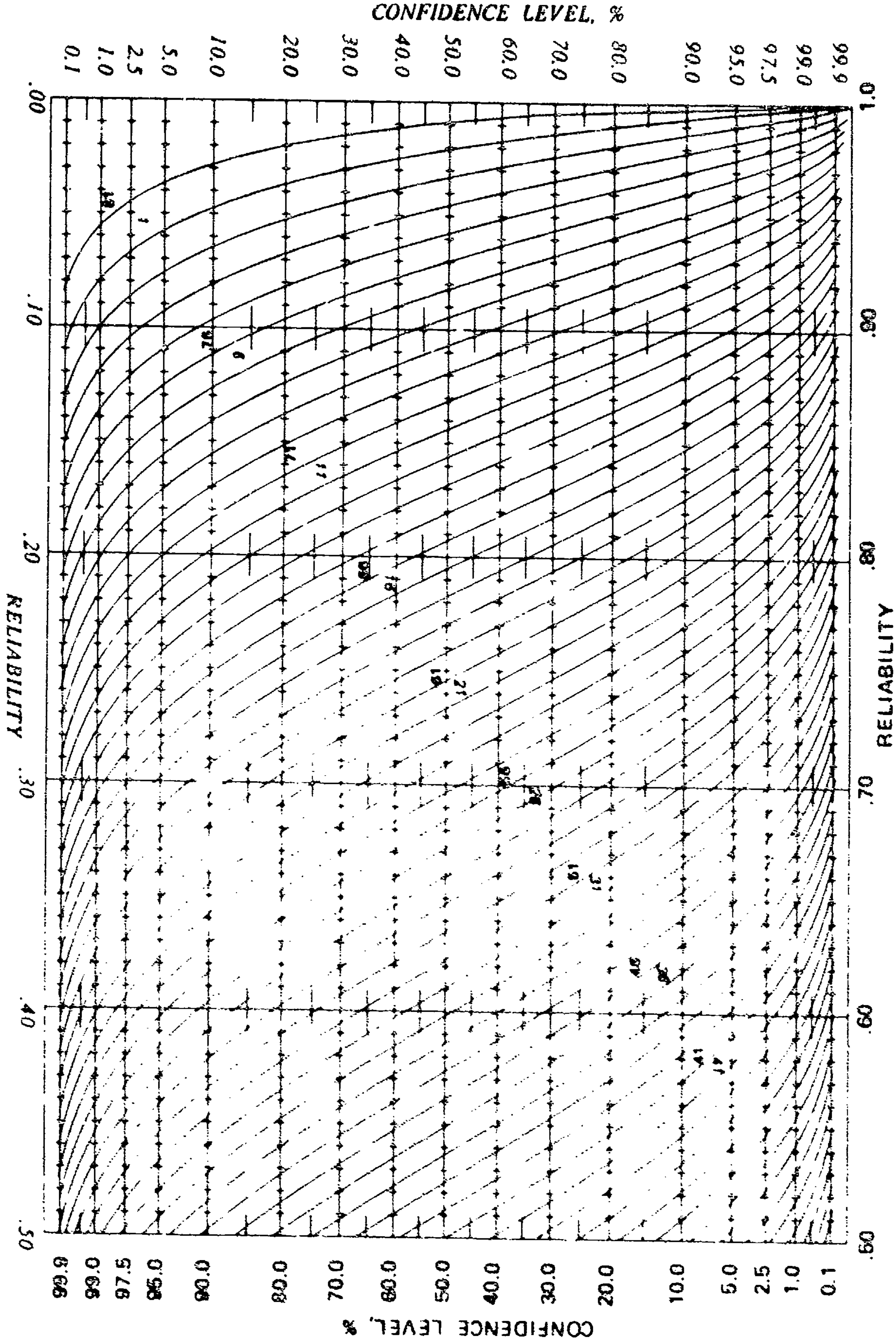

FIGURE 81. Confidence Level and Reliability for N = 81.

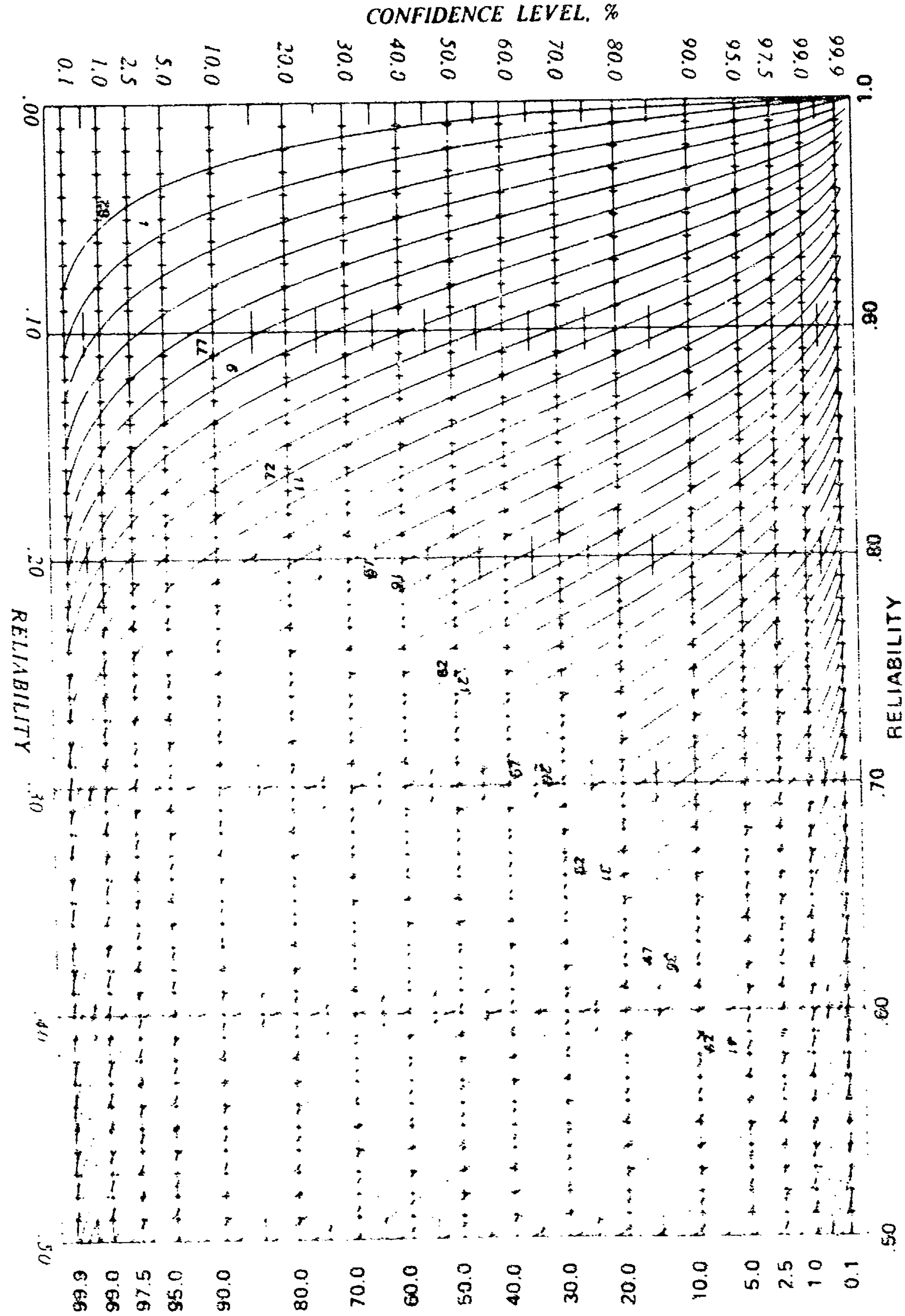

FIGURE 82. Confidence Level and Reliability for N = 82.

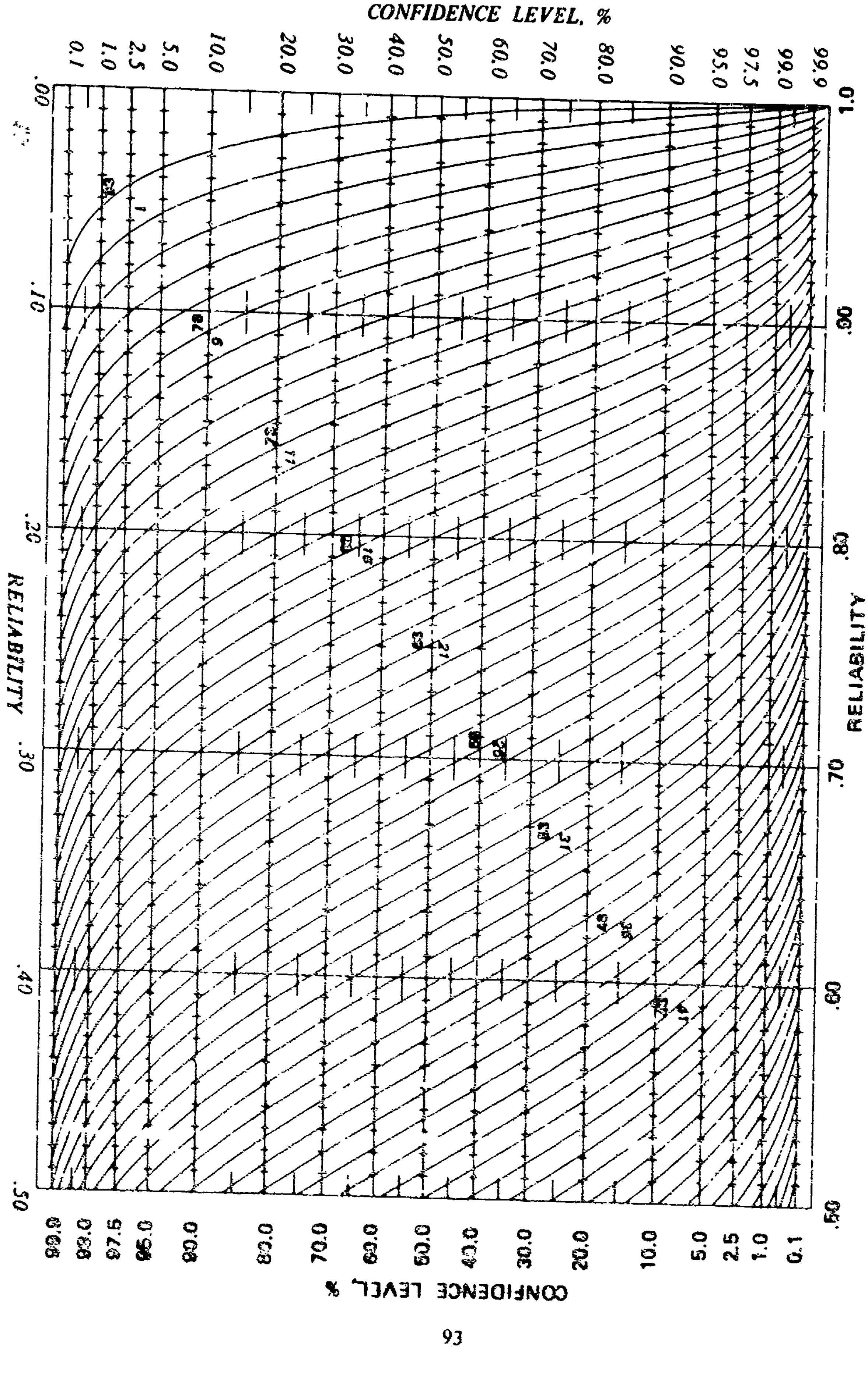

FIGURE 83. Confidence Level and Reliability for N = 83.

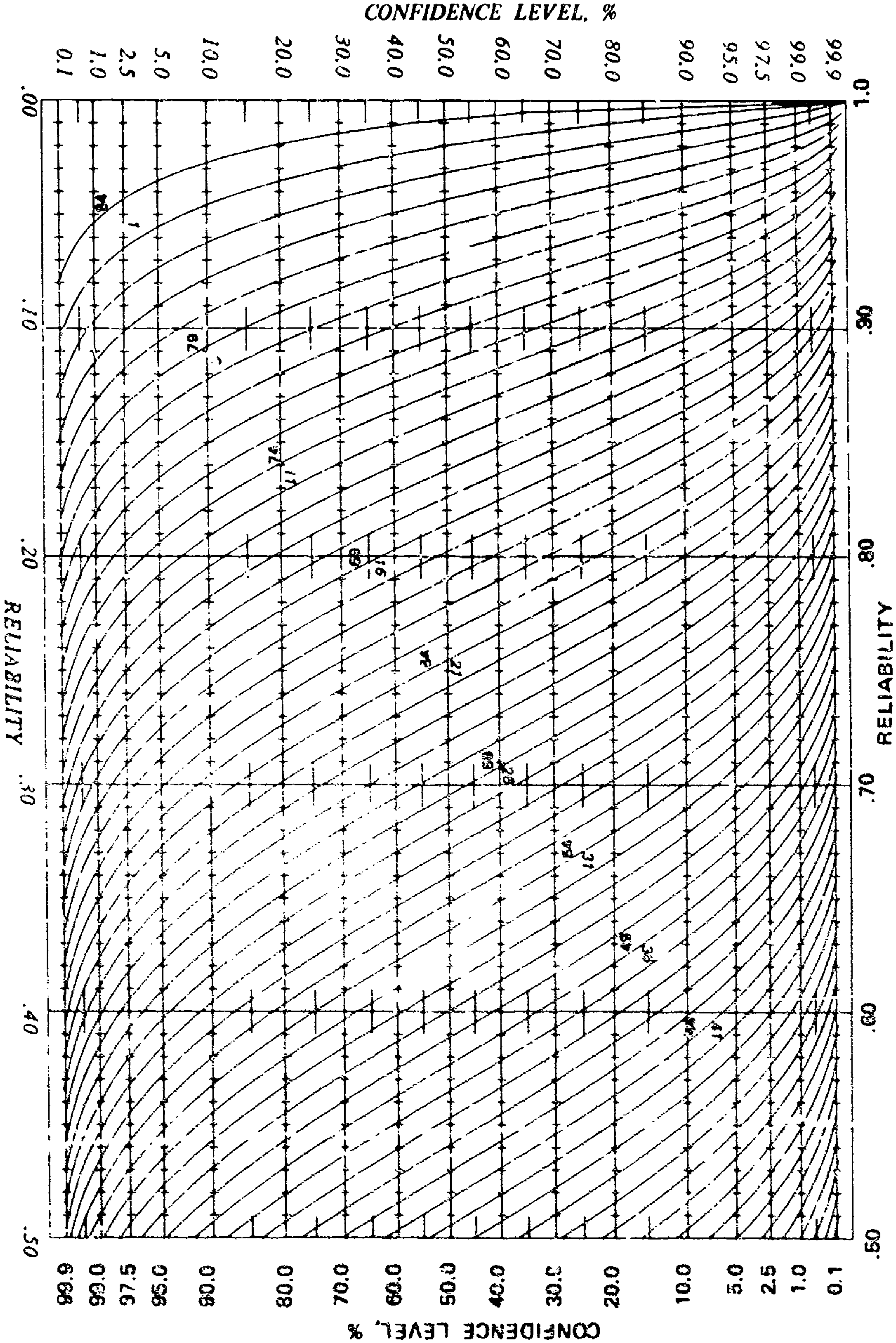

FIGURE 84. Confidence Level and Reliability for N = 84.

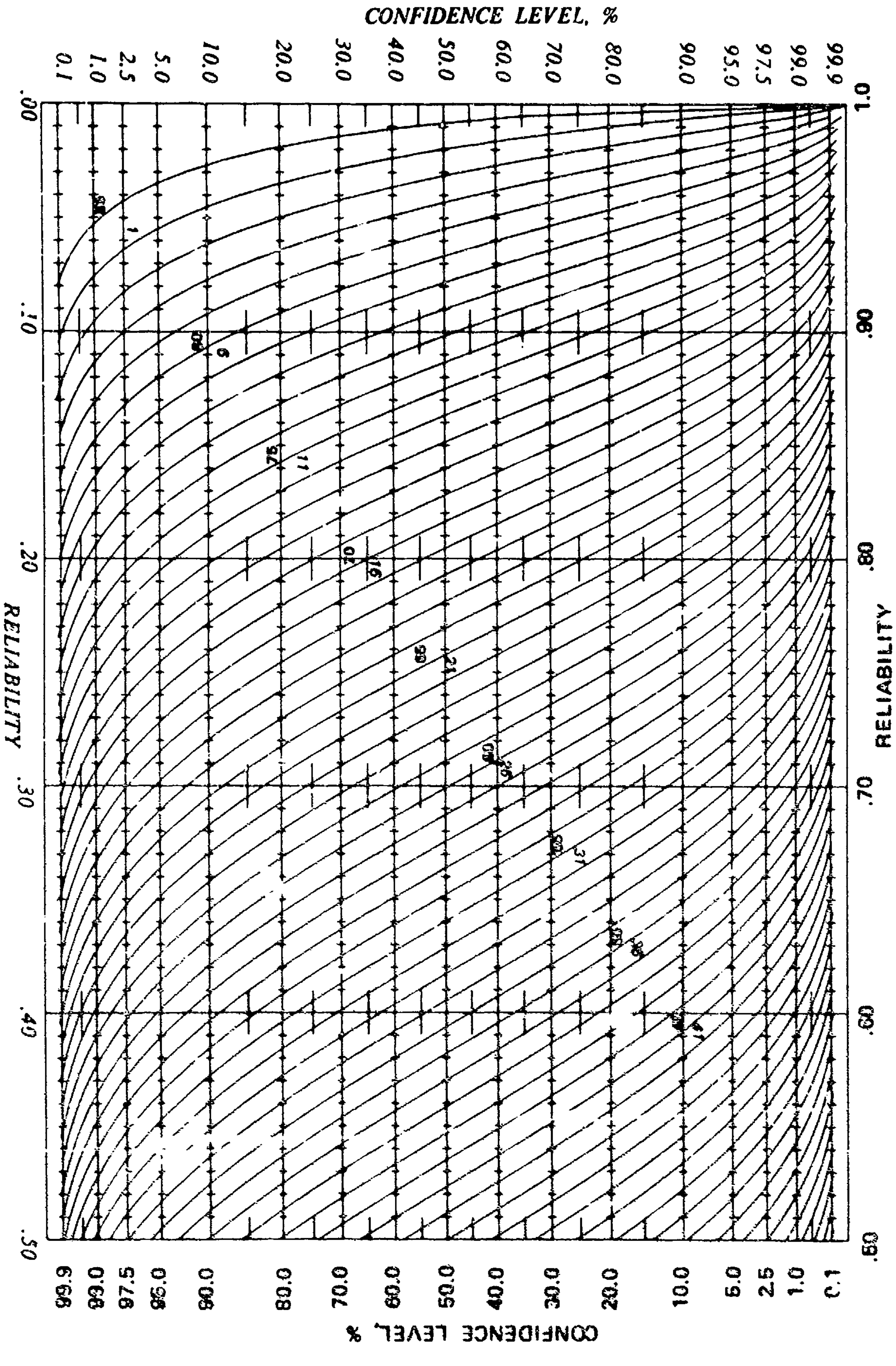

FIGURE 85. Confidence Level and Reliability for N = 85.

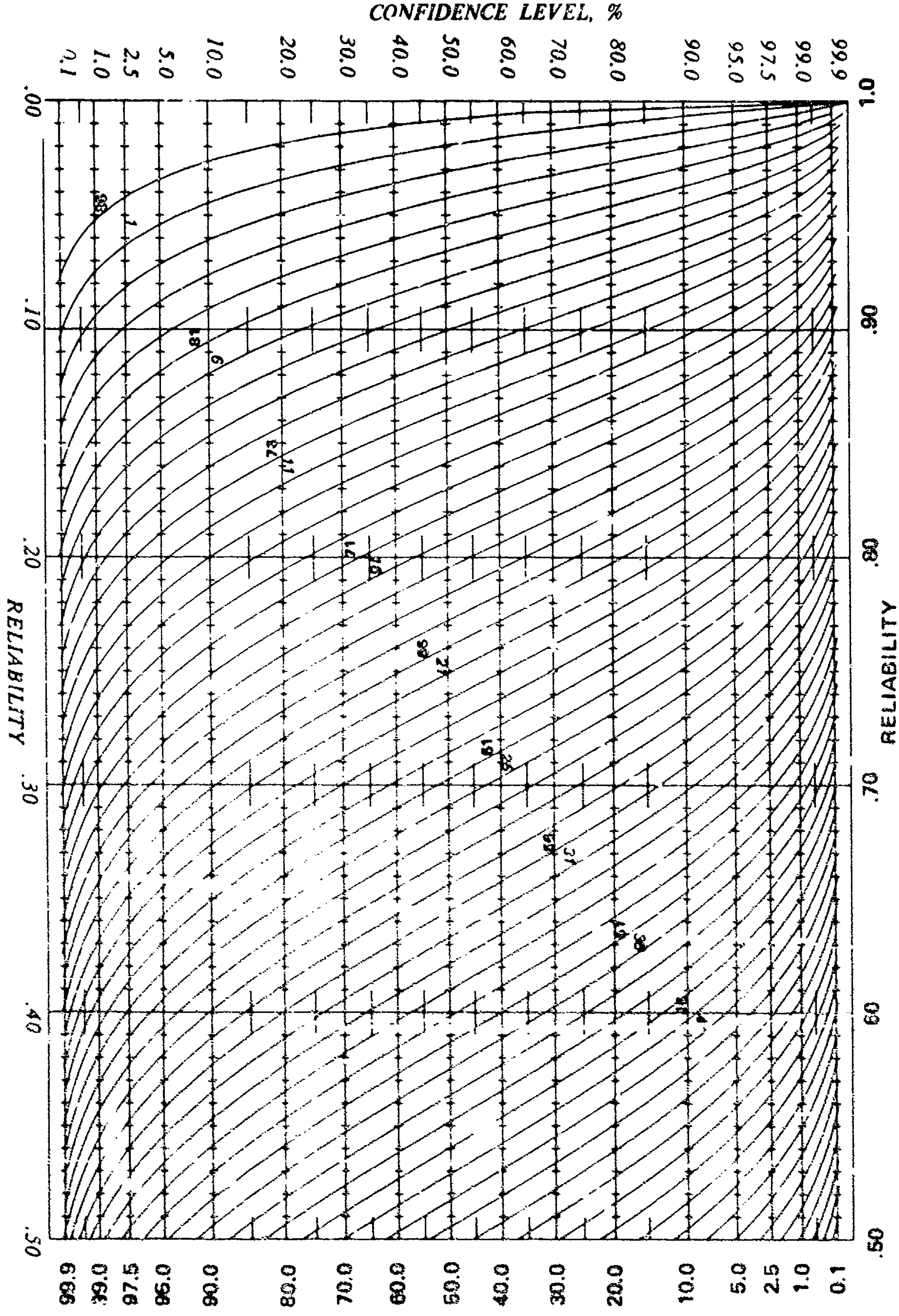

FIGURE 86. Confidence Level and Reliability for N = 86.

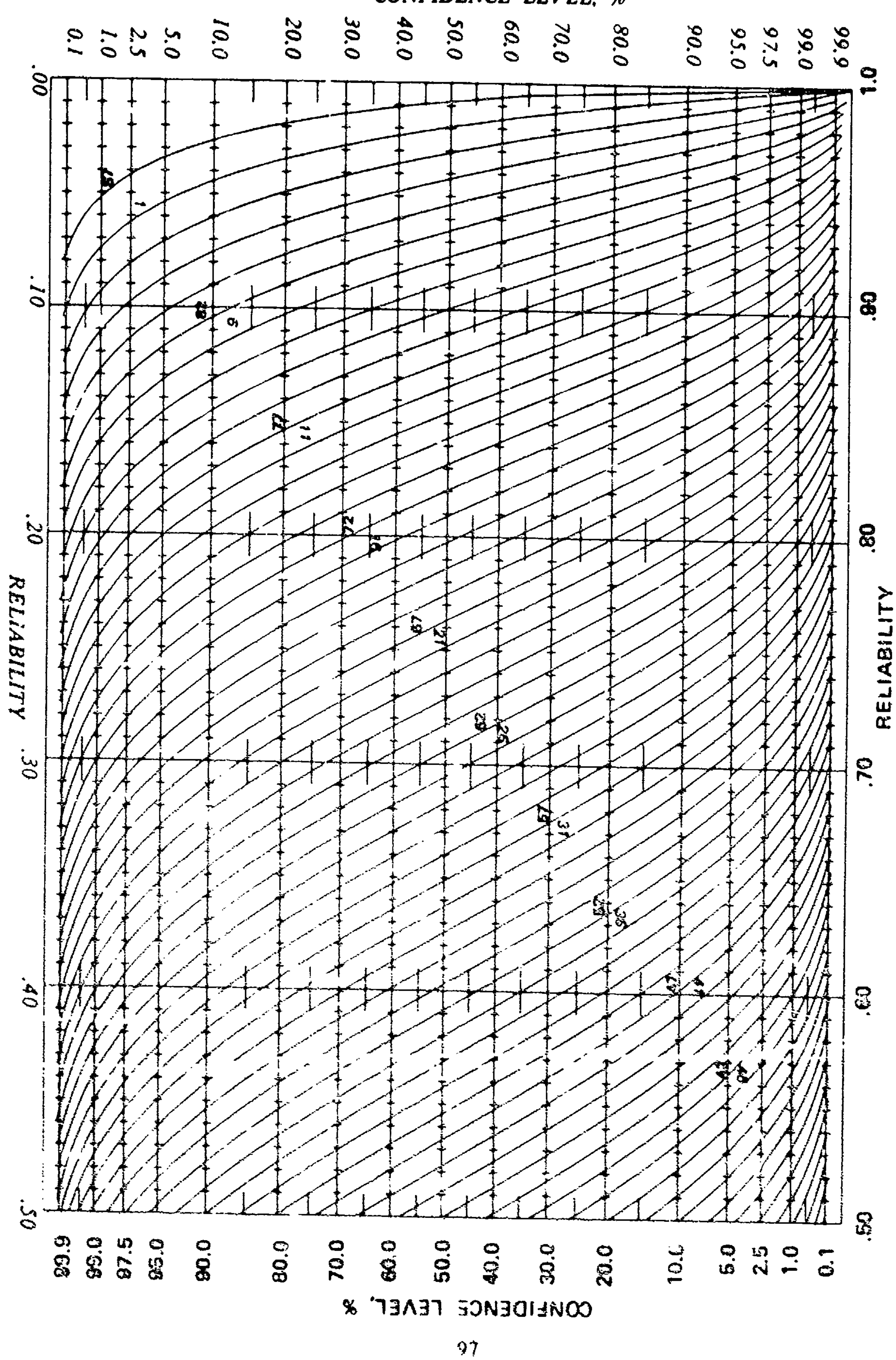

FIGURE 87. Confidence Level and Reliability for N = 87.

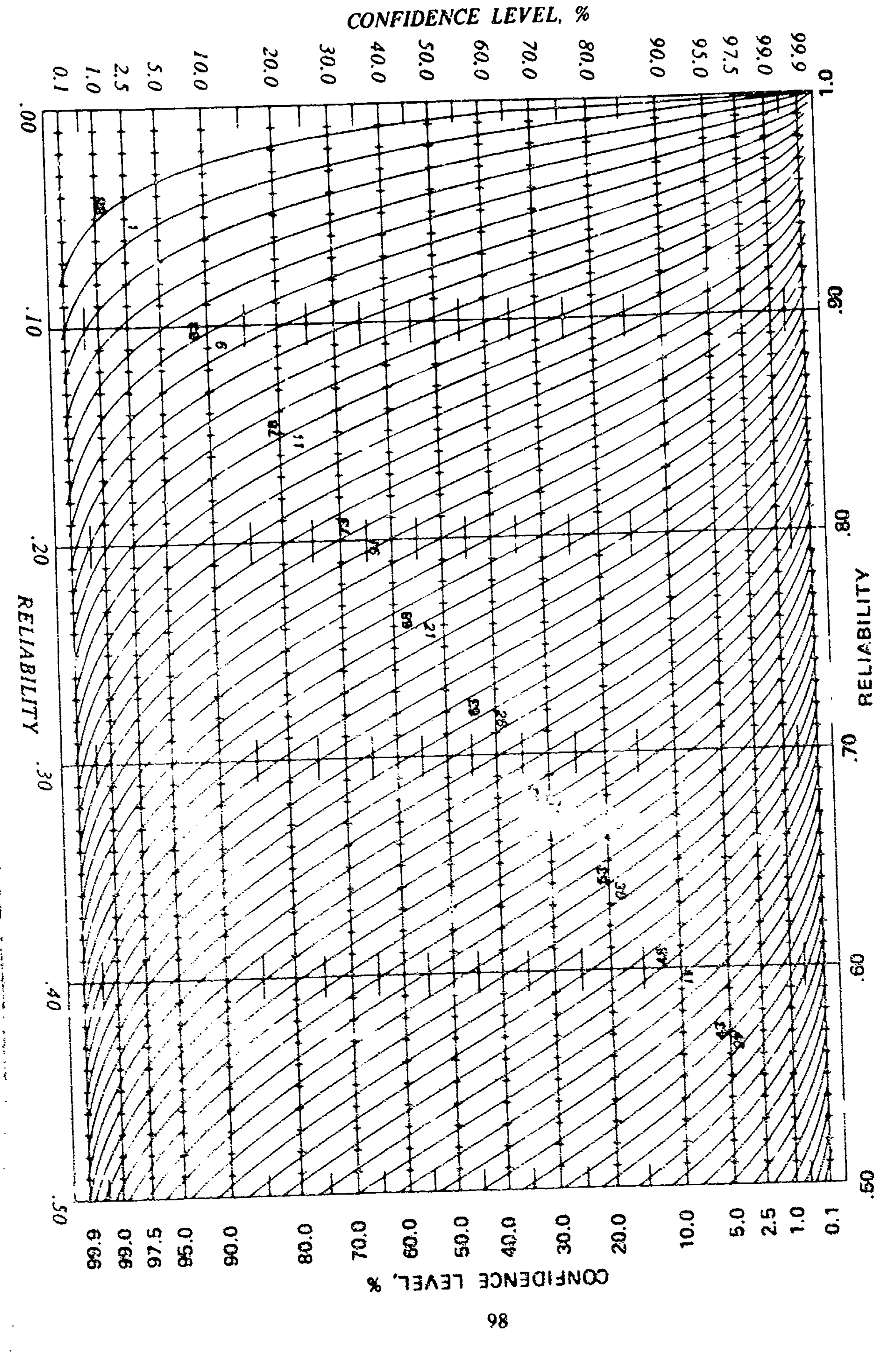

FIGURE 88. Confidence Level and Reliability for N = 88.

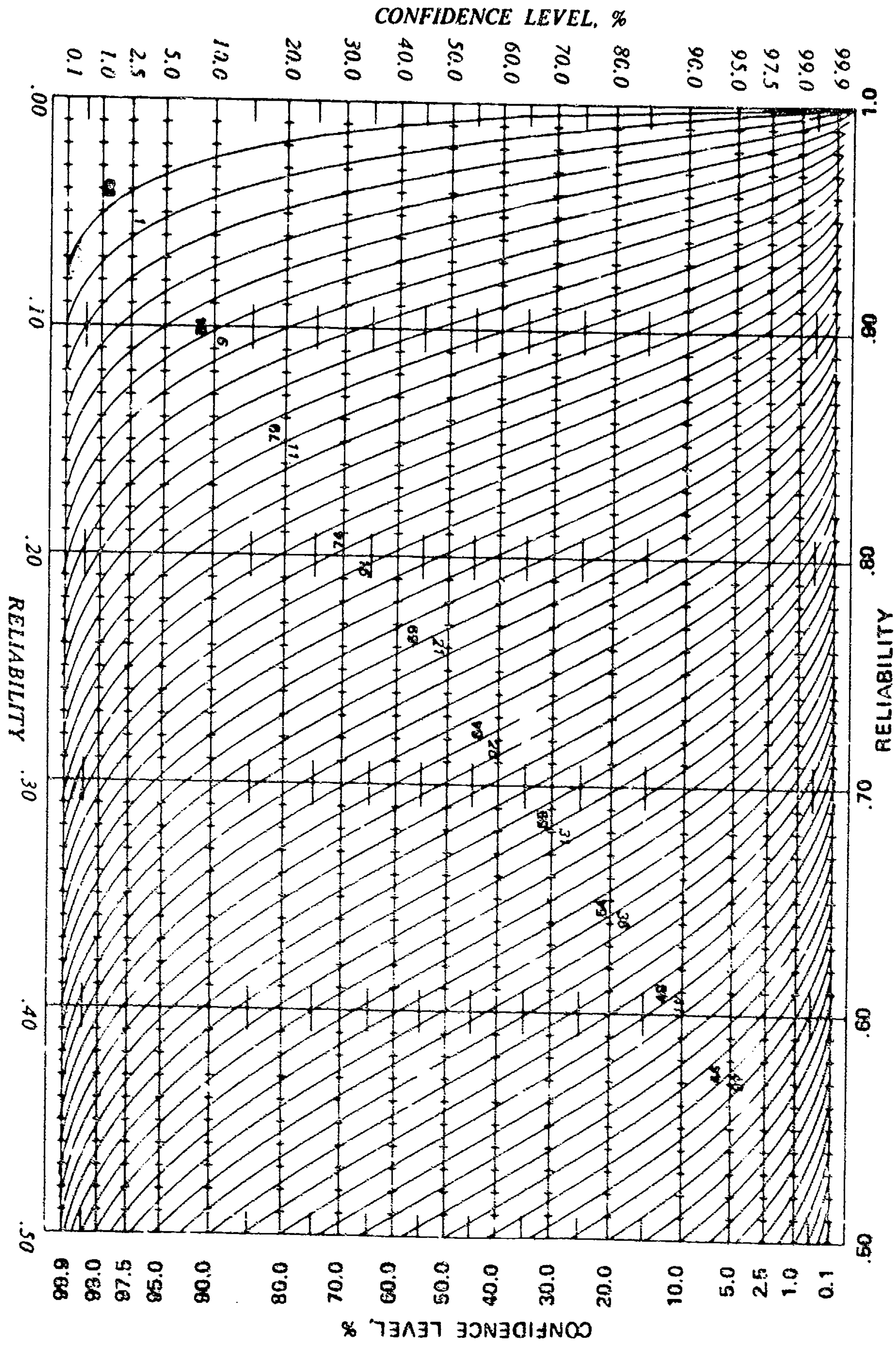

FIGURE 89. Confidence Level and Reliability for N = 89.

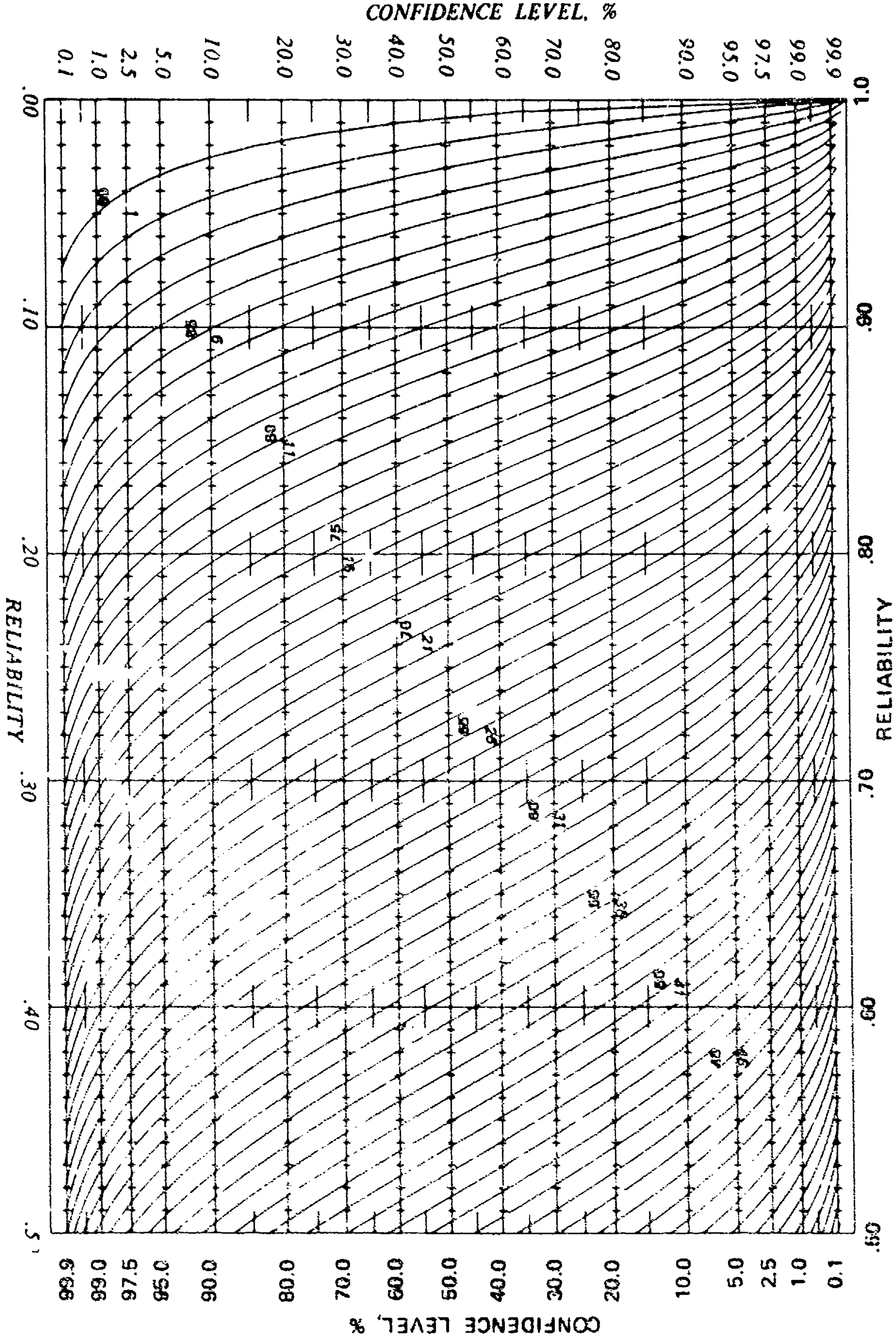

FIGURE 90. Confidence Level and Reliability for N = 90.

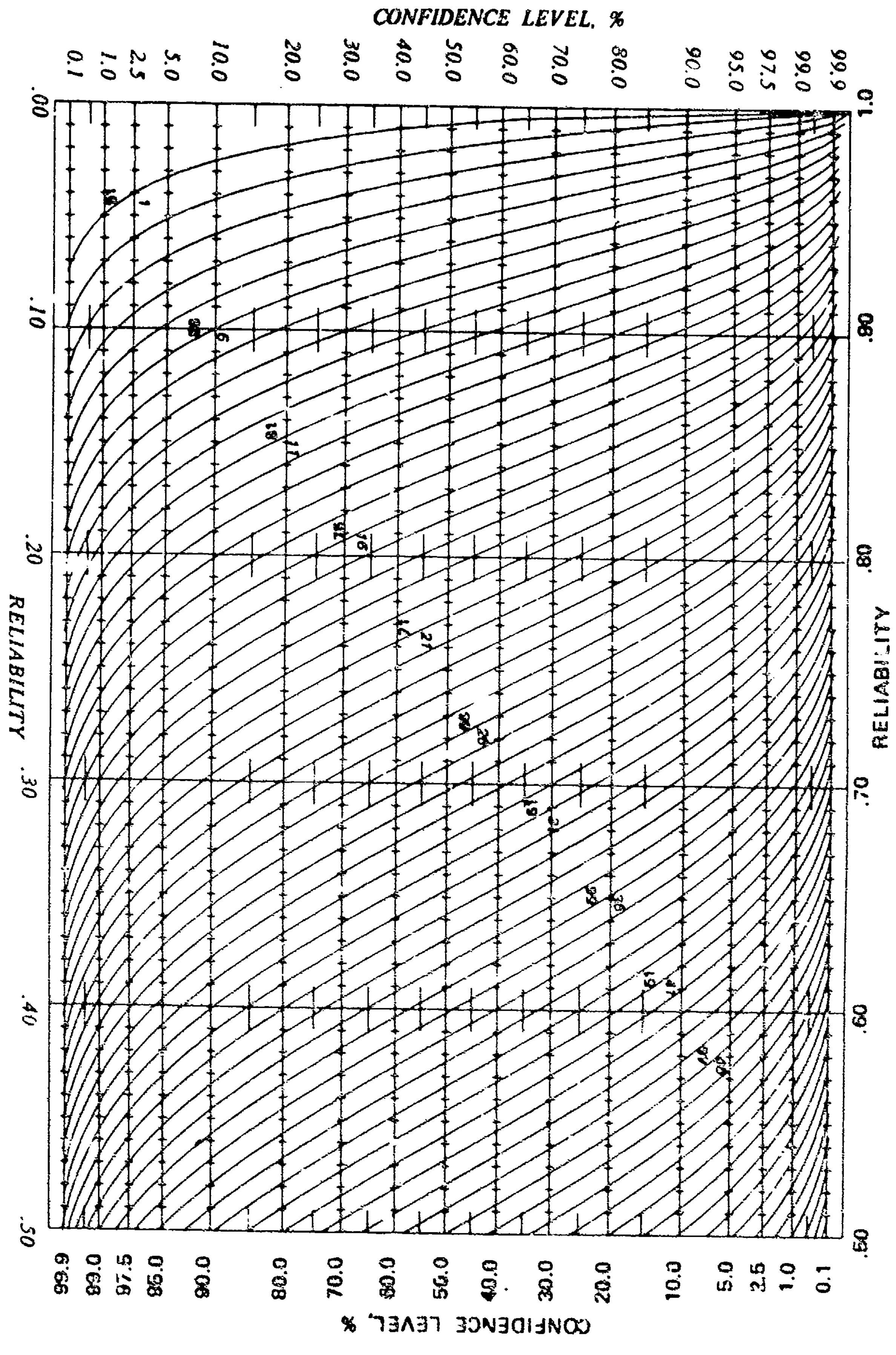

FIGURE 91. Confidence Level and Reliability for N = 91.

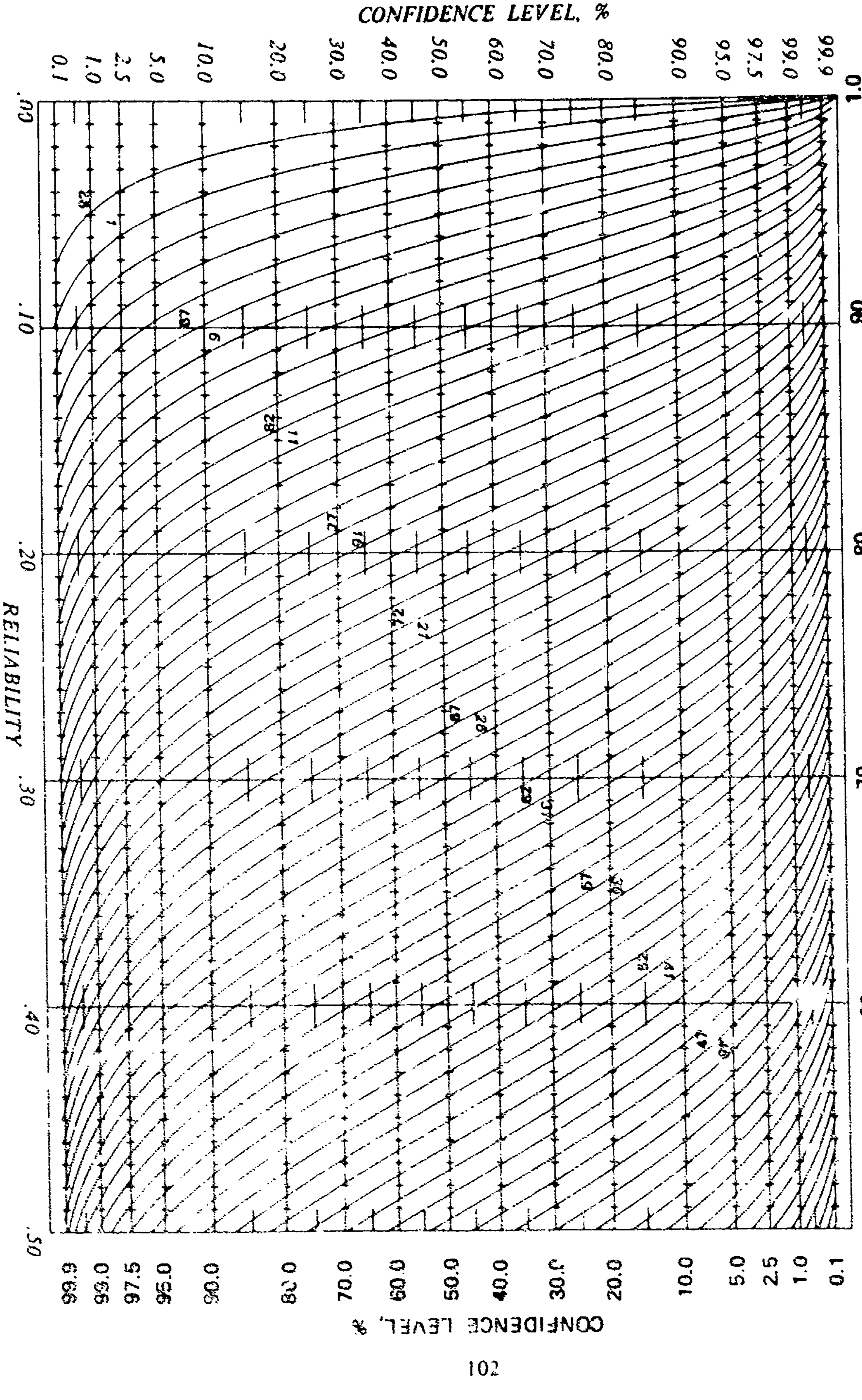

FIGURE 92. Confidence Level and Reliability for N = 92.

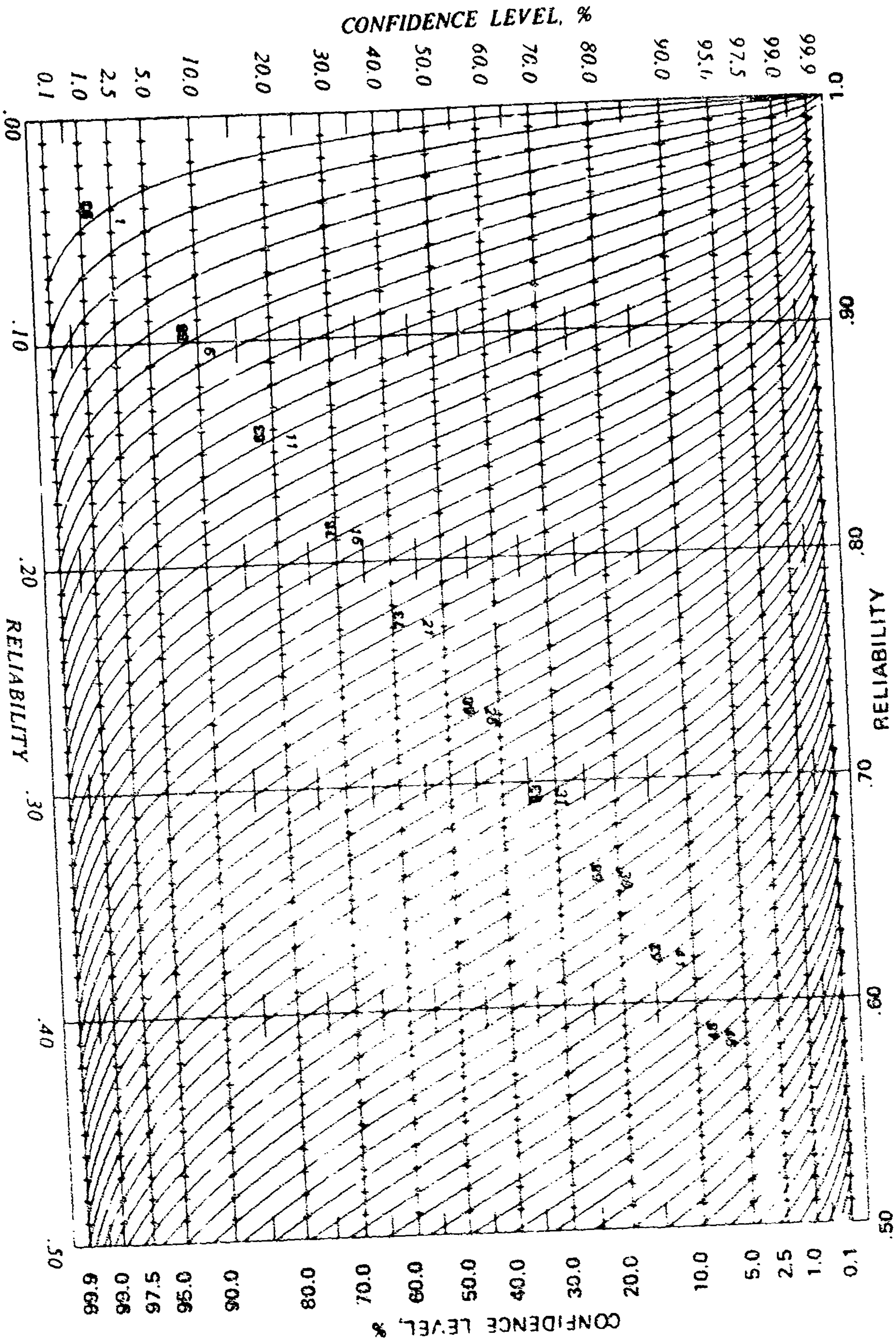

FIGURE 93. Confidence Level and Reliability for N = 93.

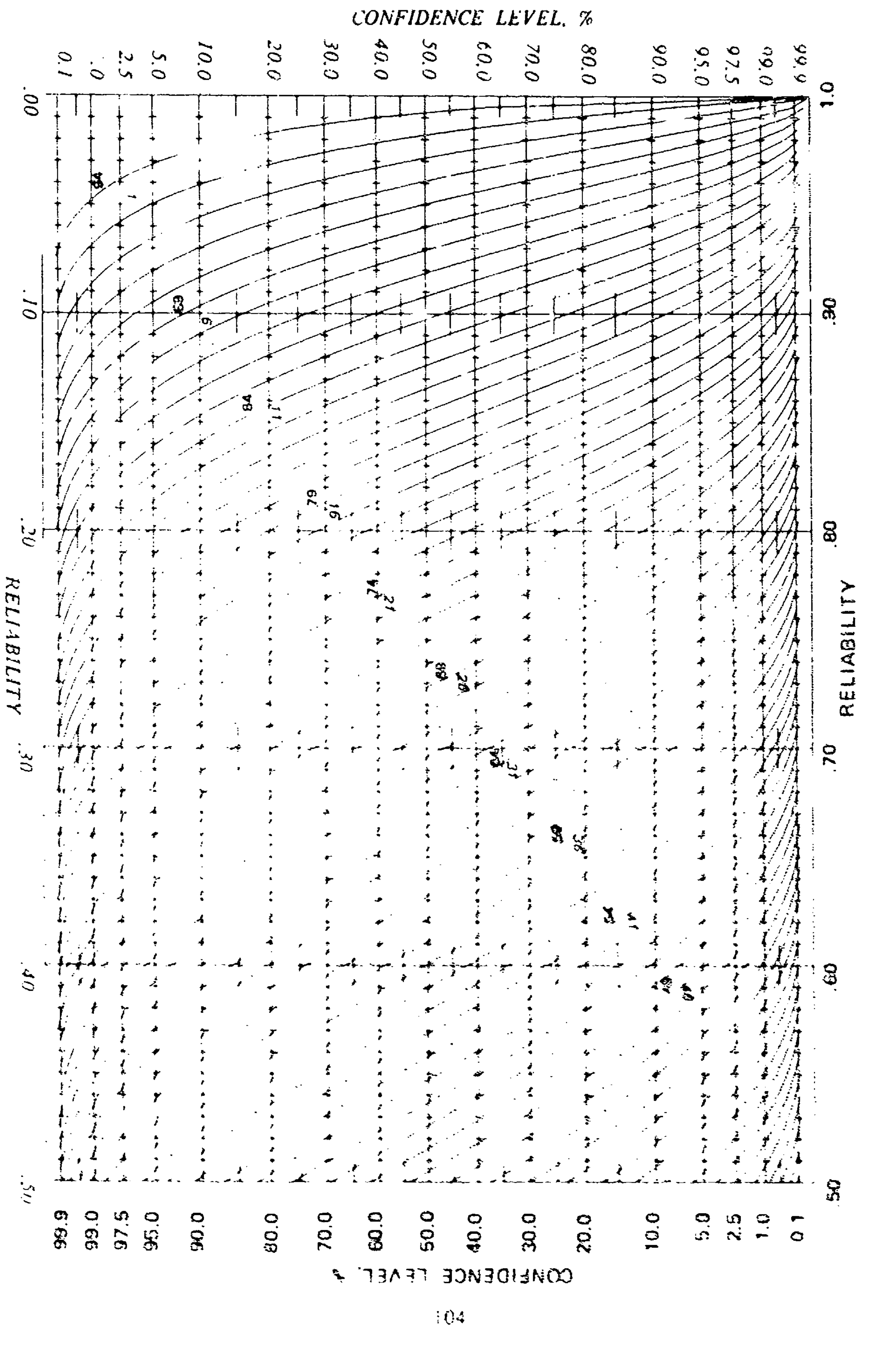

FIGURE 94. Confidence Level and Reliability for N = 94

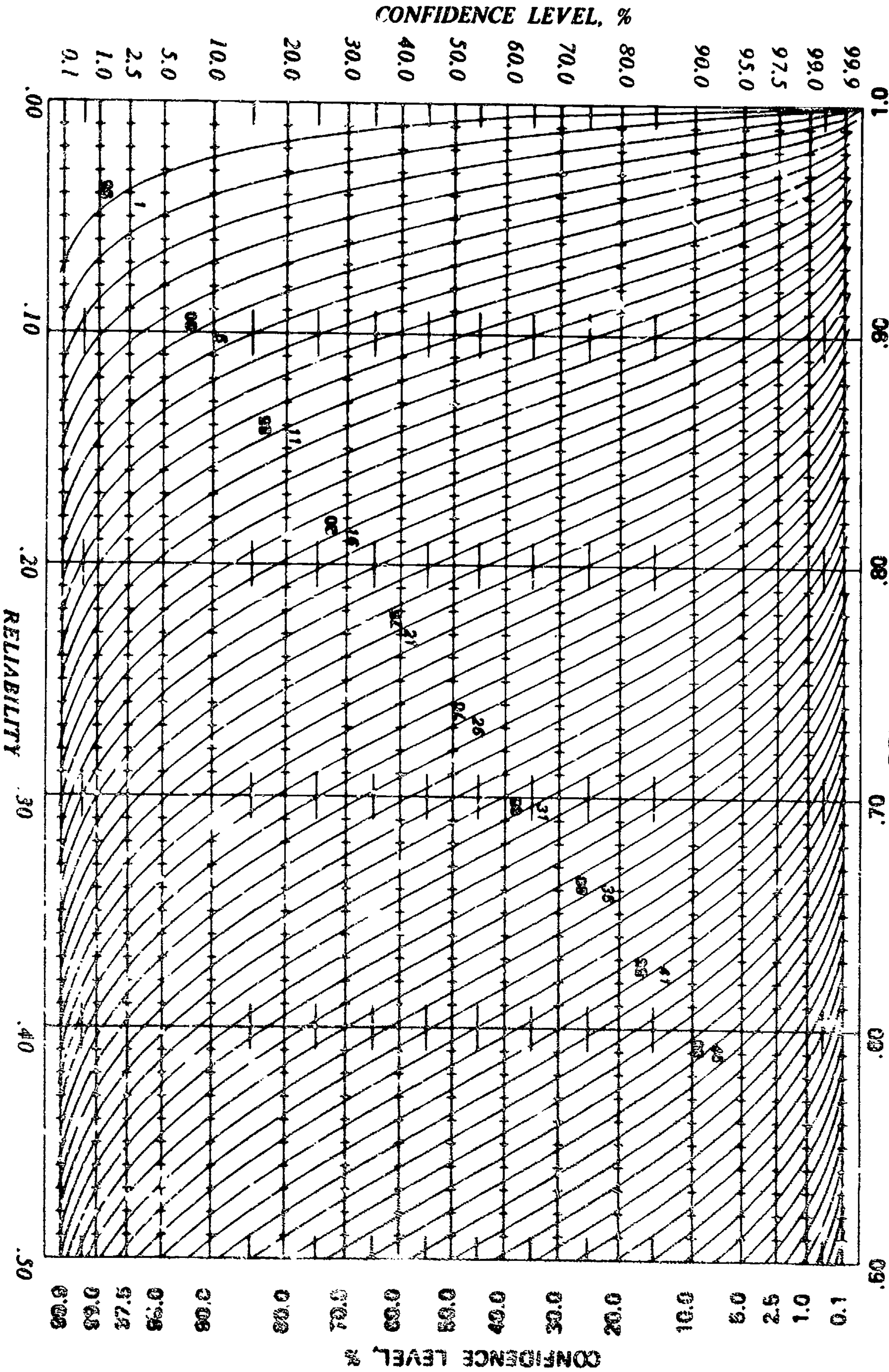

FIGURE 95. Confidence Level and Reliability for N = 95.

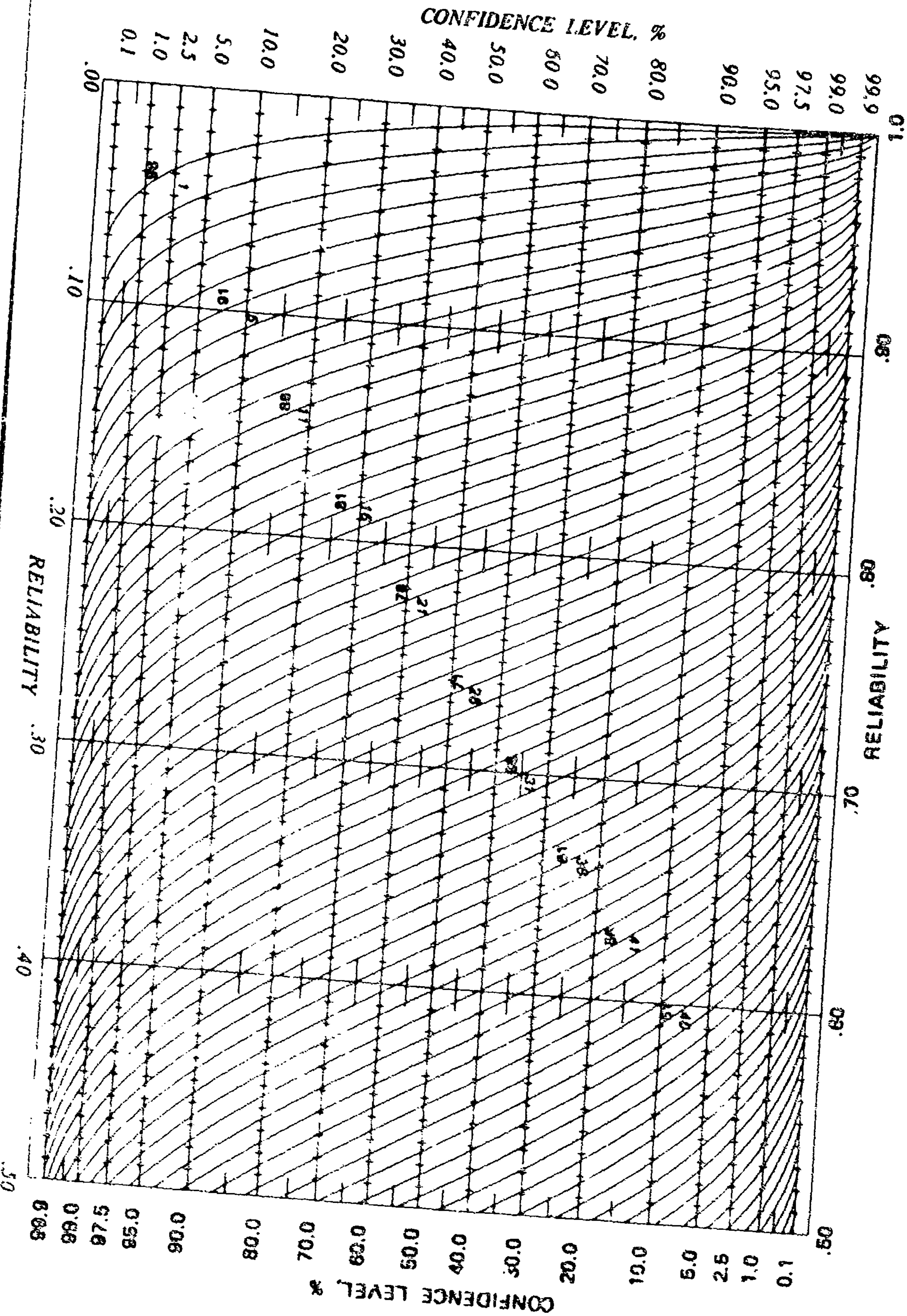

FIGURE 96. Confidence Level and Reliability for N = 96.

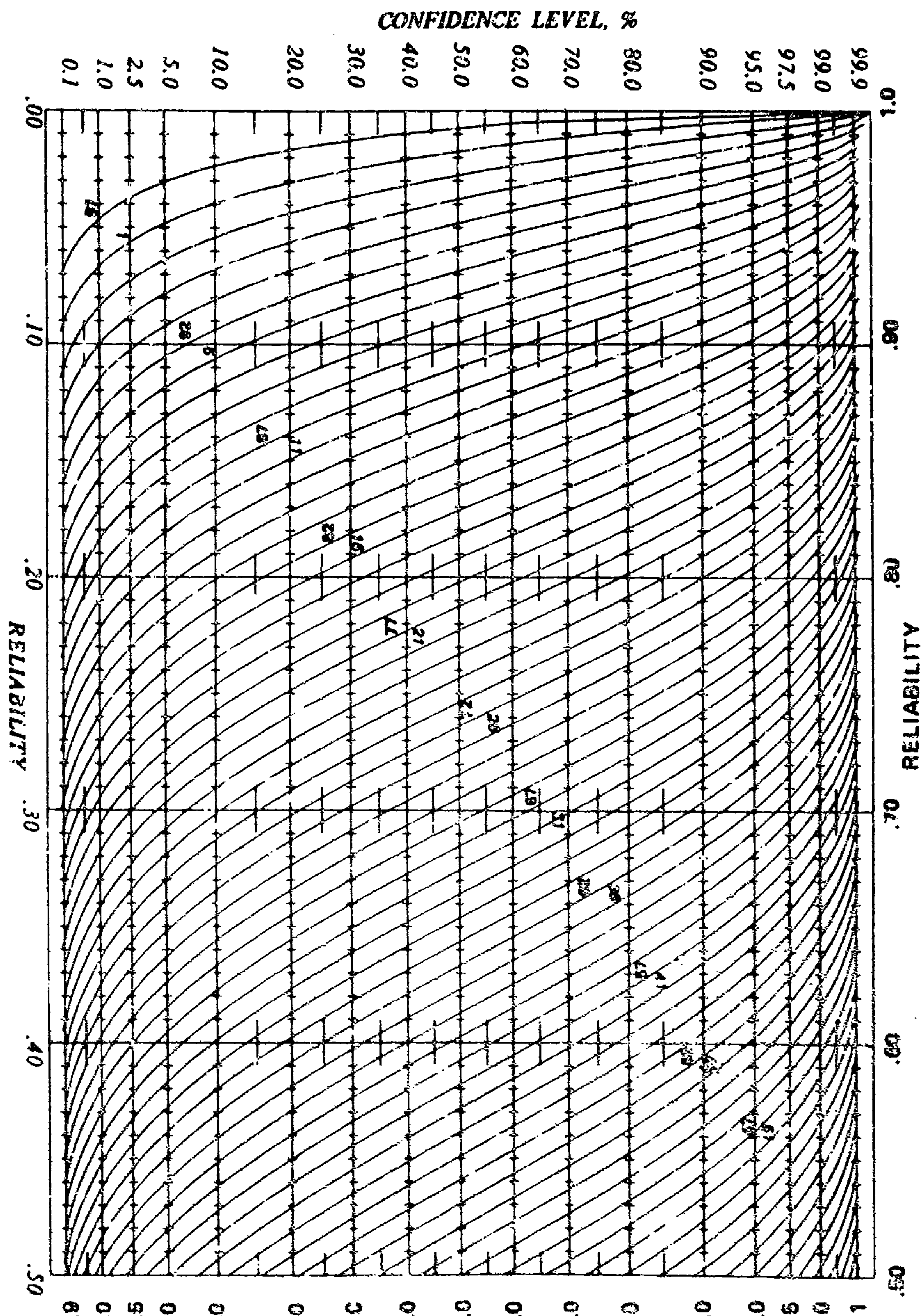

FIGURE 97. Confidence Level and Reliability for N = 97.

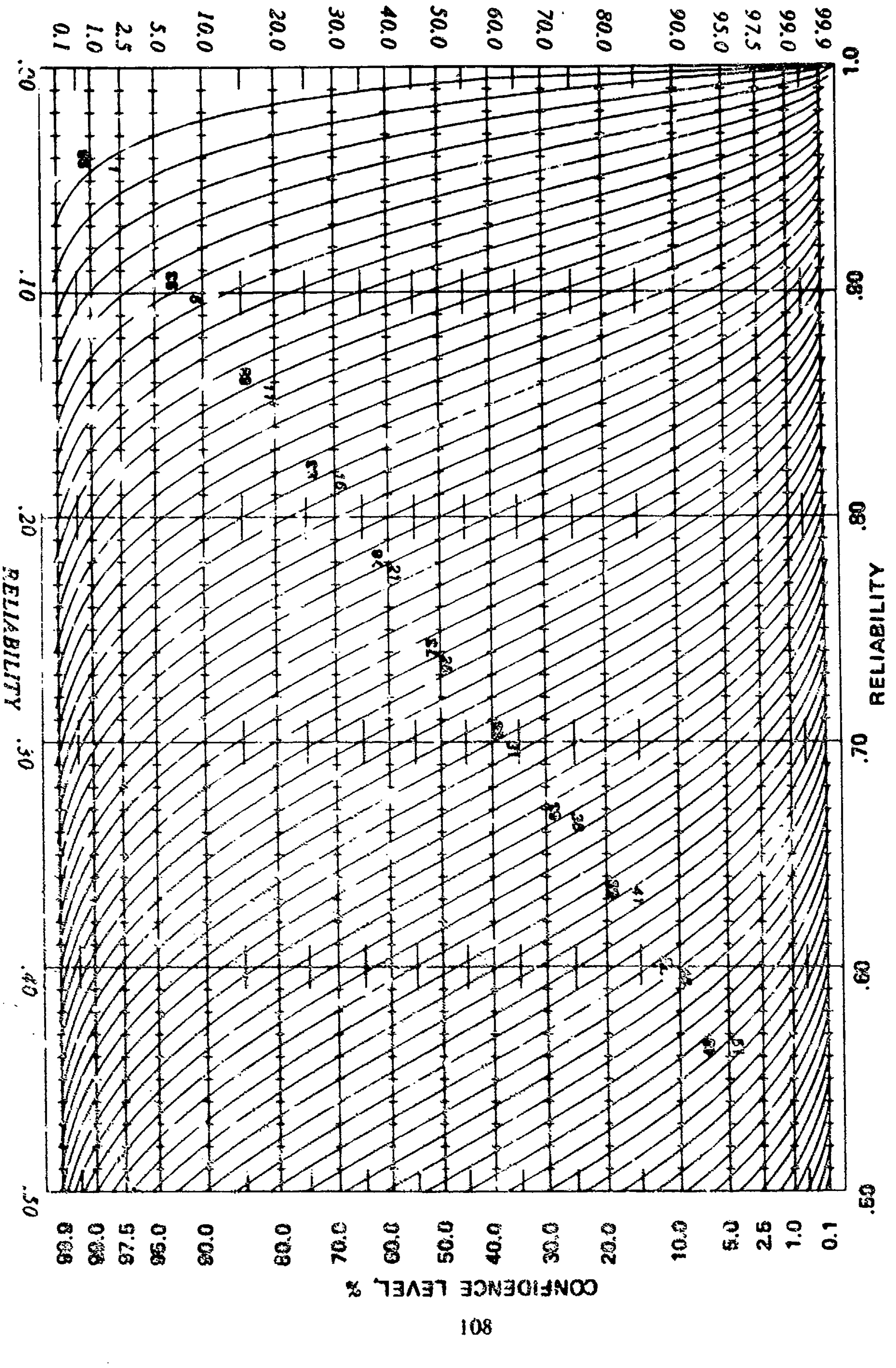

FIGURE 98. Confidence Level and Reliability for N = 98.

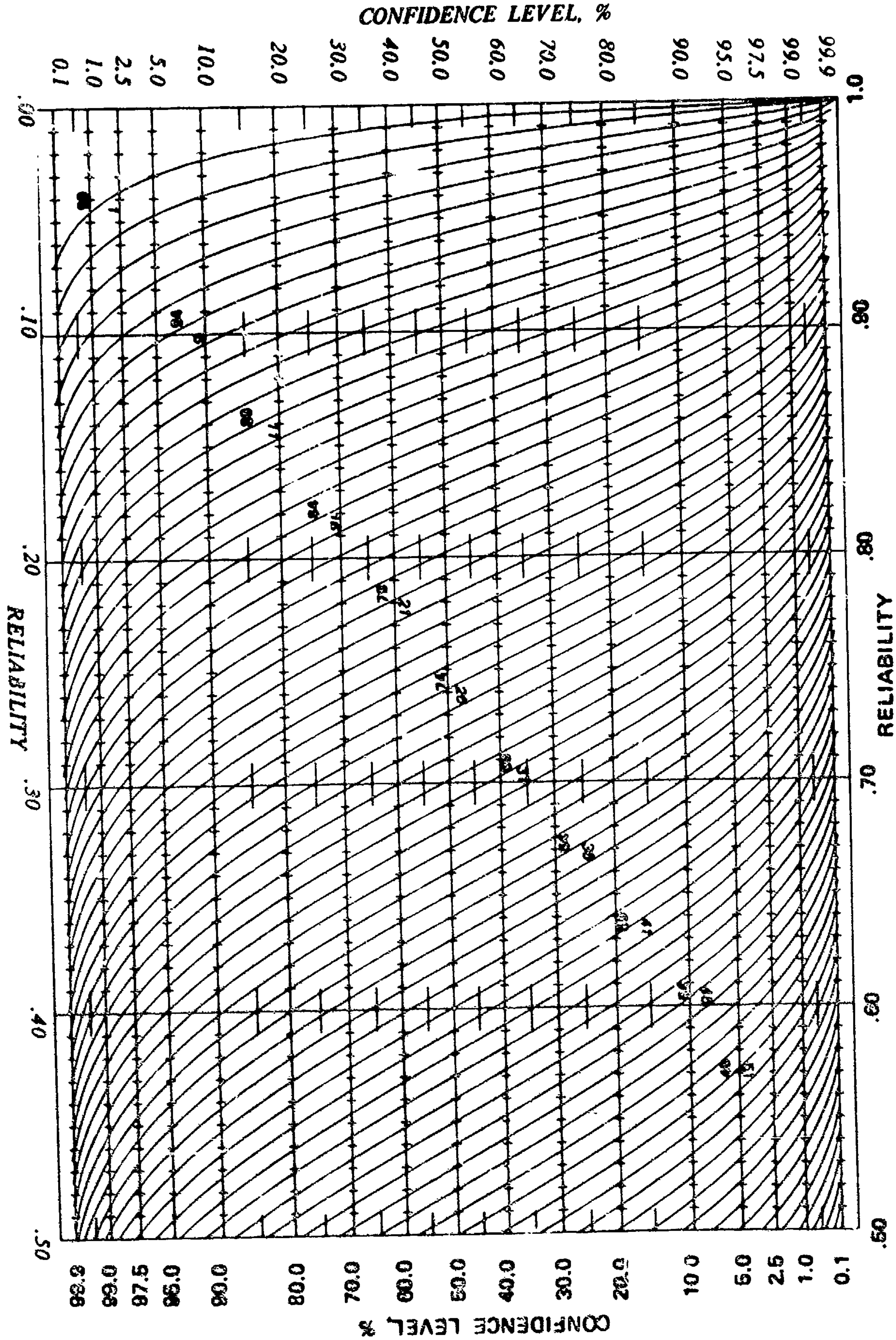

FIGURE 99. Confidence Level and Reliability for N = 99.

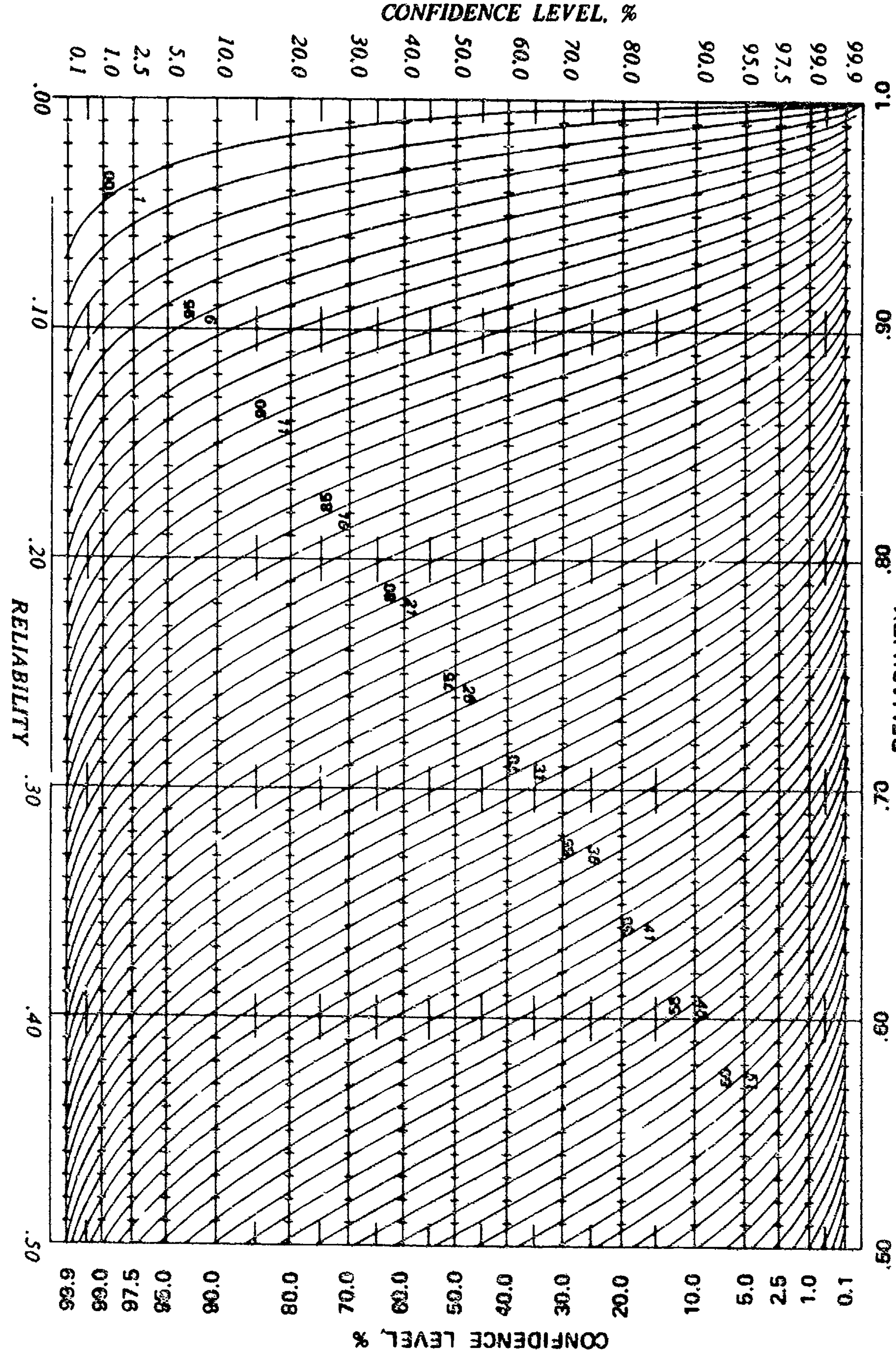

FIGURE 100. Confidence Level and Reliability for N = 100.

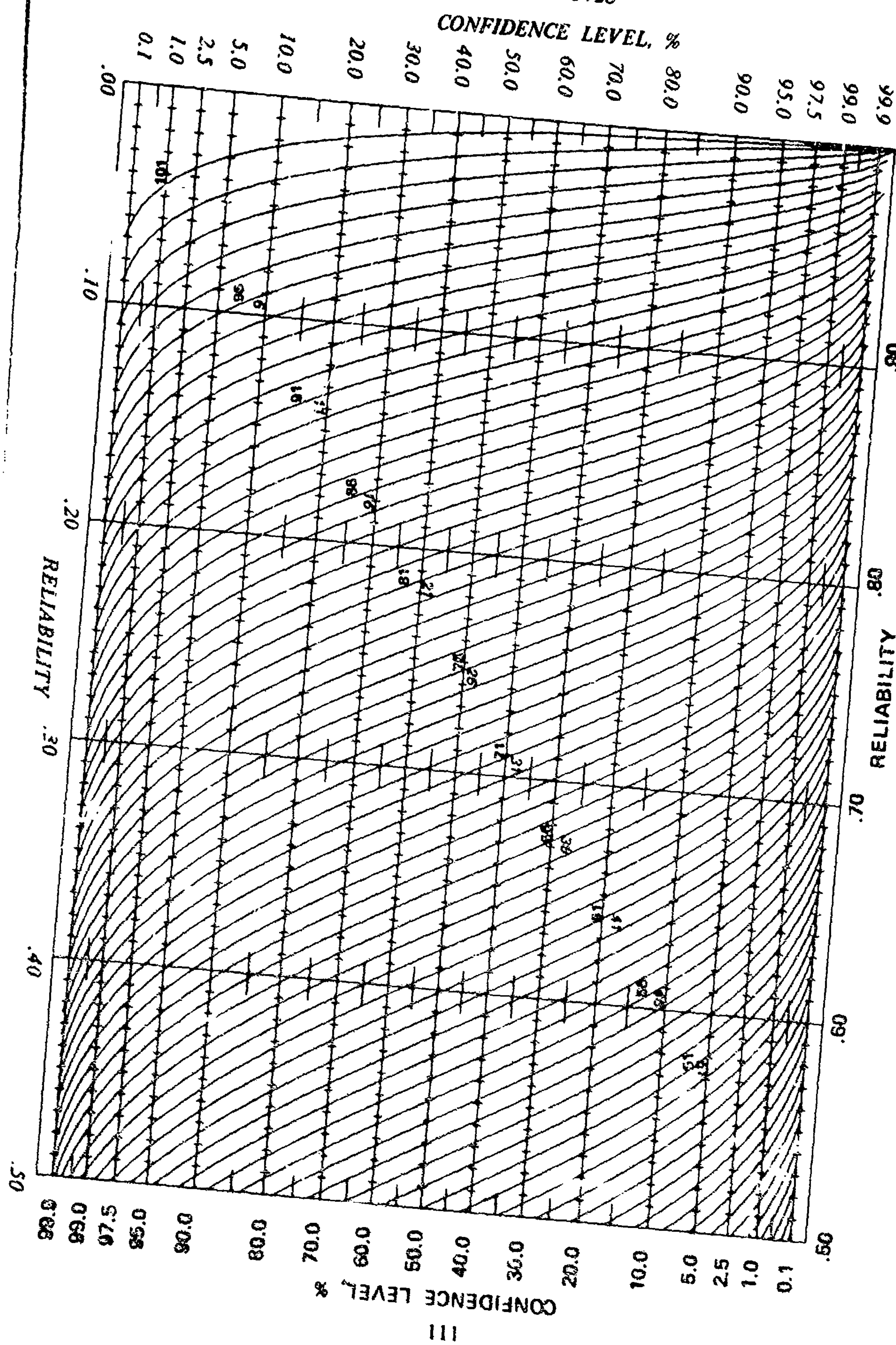

FIGURE 101. Confidence Level and Reliability for N = 101.